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Process Planning for setting up a Textile Spinning Plant for Nettle

by

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The undersigned certify that they have read, and recommended to the Institute of Engineering for acceptance, a thesis entitled "**Process Planning for setting up a Textile Spinning Plant for Nettle**" submitted by candidate in partial fulfillment of the requirements for the degree of Masters in Energy System Planning and Management in Engineering

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ABSTRACT

Of the export products from textiles sectors exported from Nepal, goat's wool or Pashmina and Himalayan Nettle or Allo are very unique to Nepal and popular in the first world countries. Residents of hilly areas have extracted Nettle fiber and spun fiber to weave products. There seems to be a bottleneck in the spinning process in this technology. This research is focused on the technical and financial aspects of building a model Allo spinning enterprise. The study can be focusses on two parts. First part focuses on the benchmarking test of the pre-existing machines for Allo processing thereby finding the processes yields, energy inputs, human resources and utility flow into this Allo processing enterprise in Nepal. The costs of each manual pre-processing were found and manual spinning process seemed to be the most labor intensive. Alternative, mode of spinning has been established by carding and spinning the fiber using industrial machinery. Based on raw material available in 15 districts, the most cost-effective district was identified to source the raw material, Pyuthan district was selected and the output plant capacity of 35 ton was defined. Floor plan of factory shed was designed with 3 sets Cooking Vessel, 3 sets Beating Machine, 2 sets Hackle Machine,4 set Carding Machine and 63 NMC 10 spindle Charkha were placed in product layout fashion in 7308 square meters main factory shed. Total 31 manpower of different levels, daily 421.5 KWhr electricity at 58.02 KW peak power, 3072 ltrs water and 44.88 kg NaOH can produce 125.5kg yarn daily. The capital investment including civil works, machinery asset and cost of initial management was deduced and yearly expenses was calculated based on the utility usage above. Yearly expense was seen to increase due to land lease, incremental salary to staff and depreciation in the machinery asset. This thesis projects a 15-year financial plan including all the asset, operational expenses, capital structure management. Increasing yearly revenue was projected based on 21-year average increase of gross value added in manufacturing sub sector of Nepal. The net income for each year was calculated and 20% tax was paid. The profit after tax was projected for 15 years into a cash flow diagram. Upon study of 15-year cash flow diagram, the project was found to break even at 4^{th} year of commencement and the internal rate of return was found to be 56%, thereby confirming the financial feasibility of the project. This model techno-financial plan will be a baseline document for any government/public/private company to refer to when setting up similar small-scale industry.

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ABBREVIATION

ΔL : Increment in land lease

ΔS : Increment in Salary

APC: Allo Processing Center

B : Total Cost of Machinery Asset

C : Cost of yearly operation

C+C2 : Cost in Second year

C1 : Cost in Initial management

C2 : Cost of loan financing

Cc : Cost of Conversion Yearly

COVID 19 : CoronaVirus Disease of 2019

D : Yearly depreciation

GDP : Gross Domestic Product

GVA : Gross Value Added

H2O : Water

HCl : Hydrochloric Acid

I : Net income first year

IRR : Internal Rate of Return

KUKL : Kathmandu Upatyaka Khanepani Limited

KVA : Kilovolt ampere

Kw: Kilowatt

Kwhr : Kilowatt hour

ltrs : liters

MCDA : Multi Criteria Decision Analysis

NaCl : Sodium Chloride, Common Salt

NPV: Net Present Value

PAIT : Profit After Income Tax

PBIT : Profit Before Income Tax

R: Revenue every year

SOYD : Sum of Years' Digits

VFD : Variable Frequency Drive

y-o-y : Year on Year

CHAPTER ONE: INTRODUCTION

1.1 Background

Ready-made garments accounted 39% of Nepal's total overseas export, bringing in Rs. 11.5 billion (the then 153.1 million US dollars) in fiscal year 2057-58 BS making a fair share to countries economy (SAWTEE, 2006). Ready-made garment industry had been a promising industrial sector, but, due to decreasing market share, 60 per cent of the textile mills had closed down and the remaining mills were operating only at 30 per cent of the capacity. Production of textiles in the 2000-2001 AD was 20 million meters, which is only enough to meet only 5.7 per cent of domestic demand; as Nepal's domestic demand of textile was estimated at 350 million meters, major remaining share was to be supplied by import (UNCTAD, 2002). Nepal has not been able to produce textile fabric on its own though readymade garment have given Nepal good business. Adding to it is phase out of free trade quota had previously made it easy for Nepal to establish in the field of export, after 31 Dec 2004 under Agreement on Textiles and Clothing. Nepal is thriving itself into previous establishment.

Textile weaving is a deep-rooted source of economy, which is widespread even in the rural livelihood of the country. Besides organized textile mills in the formal sector, small and cottage household weavers are also major sources of textile production. Majorly, fabrics of wool (sheep and goat), cotton, jute, silk and Allo (Himalayan nettle) are produced in Nepal (CBS, 2013). Of these, goat's wool or Pashmina and Himalayan Nettle or Allo are very unique to Nepal and popular in the first world countries.

Nettle processing is prevalent at various hilly districts of Nepal. Residents of hilly areas have extracted and spun their fiber to weave products. The specialty of Nettle is its strength and durability. As its raw material is found abundantly unutilized in hilly forests of Nepal, yet locals have been harnessing it in limited amount due to very tedious traditional techniques.

1.2 Statement of Problem

With the consistent decline of textile yarn manufacturing, it is explicit that Nepal's self-resilience is decreasing day by day. This decline is seen in form of numbers, total fabric

production in 2000-2001 was 20 million meters which is 60 million meters less than that of 1990-1991 (UNCTAD, 2002). Harnessing the underutilized naturally existing resource like nettle can give a good response to the situation. Plus, the trade deficit is also getting higher; meaning more import and less export; the economy is adversely being affected due to easy access to manufacturing giants of the world, China and India. India continues to command a major share in Nepal's foreign trade. With Indian economy's growth accelerating and manufacturing as well as industrial base enhanced further and strengthened. This proves there definitely is an ease of import with India and the advantage of having world's largest democracy in Nepal's south can be used to boost the technical competence of producing a fabric unique to Nepal and popular in first world.

Domestic demand of Nettle yarn was created in Carpet industry. Allo is the best alternative to other fibers used in carpet making because of its quality and natural availability. However due to processing problems and higher cost, its usage is less than hemp and other fiber. For this, it must be made sure that the fiber processing technique is optimized as per the demand of industry stakeholders (Joshi, 2010). It is established that total consumption of Allo by carpet manufacturers is approximately 2,79,312 kg per annum. Only 240 are currently operating and from among them, only 44% i.e., 105 are using Allo in manufacturing carpet. The remaining 56%, when asked about the reasons for not using Allo, mentioned that low demand from customers and inconsistencies in the supply side are the main reasons for not using Allo in carpets. (Lama & Bajracharya, 2014).

Prospects of developing Nettle fabric as a unique export good seems be very promising. This has motivated many INGOs, NGOs and the government to streamline the effort to create a strong supply chain. As demand for Nepali apparels made from Nettle is increasing in international markets every year, efforts have to be made to produce Nettle threads in large volume as they serve as the base raw material for production of other Nettle products. The government plans to set up Allo Processing Centre (APC) in 10 different locations of the country to facilitate Nettle producers and promote the production of this fabric (The Himalayan Times, 2016). Micro Enterprise Development Programme (MEDEP), UNDP had supported engineers to innovate a technology for Nettle processing. It resulted into four simplified machines that can be used by entrepreneurs to increase their productivity

(MEDEP, 2016). There seems to be research gap in the technical and operational side of setting up Nettle processing textile unit as the industry imagined will be first of its kind.

1.3 Objectives:

The main objective of the research is:

- To prepare a detail technical plan for setting up a production unit that extracts/processes Nettle fiber and produces yarns out of it

The specific objectives are:

- To plan the best suited location, capacity, and scale of the industrial setup
- To prepare a plant layout for the processing setup.
- To evaluate all the resources (energy, material and labour) consumption for this textile spinning line.
- To document all the costs in establishing and operating the enterprise for analysing the feasibility in terms of financial indicators.

1.4 Scope and Limitations

Although, the impacts of dependence on foreign resource had been overlooked, it seems incumbent to work on our comparative advantage. The rationale of our project bridges this chasm. With local resource like Himalayan nettle coming into the limelight as a uniquely well branded product from Nepal through relevant industrial setup that can be developed by studying textile processing in similar scenario (as in India), the chances of extracting comparative advantage are higher. Along with it, the degrading textile industry in Nepal can see new hope with this scheme.

This research is focuses on the engineering an industrial setup; its detail design based on study of other bast based textile processing plants. The final report aims to produce a thorough documentation that can be used as a base document for development of one such textile processing industry. Along with it, details of energy and utility usage in typical textile industry will be studied. These data can be used to comparative analysis of energy intensity among other textile industry.

The research involved in the project is quite specific and precise. These constraints the study the following limitations:

1. The data used for identification location is secondary, the lack of data in this domain of work has been major issues for previous researchers too. Though, the data for yield of pre-processing is calculated experimentally.

2. This thesis can be taken as a guideline for development of textile, there is a need of verification to be done on an integrated scale, as this research integrates smaller parts of verified outputs through literature review and experimental tests. The process layout is designed based on the assumptions from literature and the study of similar bast fiber processing, as industrial setup relating Nettle yarn production is very noble.

CHAPTER TWO: LITERATURE REVIEW

2.1 Trade Deficit and Comparative Advantage

A country imports those goods, which are not available in the country and exports those goods, which have excess supply in the country. So, in the modern age, all economies are dependent economies, international trade is also considered as the vehicle of economic development (Silwal, 2008). Before 1951 AD, Nepal's traded only with India and Tibet. After 1951 AD, Nepal's trade relation expanded with many other countries like Japan, the USA, Germany, Malaysia, Singapore, Thailand, Kuwait, France, Bangladesh, Spain, etc. Nepal's foreign trade is rapidly increasing but with the increase in the total volume of trade, the trade deficit is also increasing (Kafle, 2017).

India continues to command a major share in Nepal's foreign trade. With Indian economy's growth accelerating and manufacturing as well as industrial base enhanced further and strengthened, India's share in Nepal's total merchandise trade in the last fiscal year increased to 64 percent - in 2003-4, it was 58 percent. China's trading share with Nepal also doubled in the last 5 years to 12 percent - around one fifth of the trade with India. The share of other countries continued to decline to 26 percent of Nepal's total trade last year (Ghimire, 2016). This proves there definitely is an ease of import with India and the advantage of having world's largest democracy in Nepal's south can be used to boost the technical competence of producing a fabric unique to Nepal and popular in first world. So, Nepal has to build competence buy selling/exporting unique products like Nettle by transferring/developing relevant industries in Nepal, in doing so, lessons can be learnt from technically sound neighbors India, Bangladesh and China, for industrial processing.

2.2 Textile and Clothing Sectors in Nepal

Specifically, jute farming and manufacturing used to be the oldest and main cash crop and exportable industrial product till the early 1970s, but economic viability could not be maintained in the wake of the invasion of cheap substitute like plastic. Textile industry flourishing since 1980s, had been gradually declining ever since and is in lean phase. State's policy in 1990 was to open the Nepalese market to the outside world and phase out protection given to domestic industries. In the process, a high import tariff wall was lowered and, as a consequence, domestic industries, including textile, faced severe competition from cheap

imported products. This decline is seen in form of numbers, total fabric production in 2000-2001 was 20 million meters which is 60 million meters less than that of 1990-1991 (UNCTAD, 2002). Nettle (Allo), a bast fiber like jute can be scaled up for similar market. Of 52-member textile mills associated to the then Nepal Textile Association, only 12 were in operation. Most of government owned industries have ceased to operate. There has been gradual decrease in share of manufacturing in total GDP, which reduced from 9% in 2000/01 to 6.2% in 2012/13. Under manufacturing sector, there is a structural change in its subsectors, textile manufacturing share in value added was reduced from 25.9% in 1996 (highest of all time) to 3.9% in 2011. Similar decline is seen in wearing apparels and fur sub sector, which reduced from 6.3% to 0.5%. The number of industries in textiles significantly decreased by 8% from 2006 to 2011 and by 16% from 1996 to 2011 (CBS, 2011). Textiles, which were the primary manufacturing industries in the 1996, seems to have been replaced by food & beverages and non-metallic products. Textiles, wearing apparel & fur, and leather & leather products and footwear sectors stand out as export-oriented manufacturers with more than 50% of their output exported. Despite the decline, in the year 2011/12 textiles took the lead over food & beverages as the largest exporter. Above figure do not take into account the import of raw material in sub sector. To take that into consideration, the net effect is calculated by deducting the value of imported inputs from the export/ This is represented by share of net export. Now, the food and beverage stand on the top just ahead of textile industry. This is due to the fact that imports on raw material for textile (fiber) is higher for textile sub sector. (UNIDO, 2014) . None the less, government of Nepal has been trying to promote local products like Allo and Dhaka, trying to make it mandatory for governmental officer, school teachers and student to wear textile products made in Nepal.

2.3 Major Players in textile yarn making in Nepal

Though textile is said to be the mother of all industries and textile establishments were pioneered in Nepal well before "*The revolution of 1951 (Sat Salko Kranti)*" which was started as Birat Jute Mill Strike in 1947 AD (Manandhar, 2008), one of country's oldest mill. There are basically four business groups that produce just textile yarns through. Their production sums up to 70000 ton of yarn per year (Golyan, 2017) . Apart from RK Golchha groups Arihant Multifiber Ltd and Shree Raghupati Jute Mills Ltd who also work on jute fiber to produce yarn hessian fabric, twine and jute bags (Golchha, 2019), all the other corporate

houses majorly import raw material to produce yarns as their end product. Thus, the producers are dependent upon foreign resource, plus these raw materials are usually synthetic and non-biodegradable, except for jute which is a natural bast fiber.

Studying two big spinning mills in Nepal, the following glimpse are captured. Reliance spinning mill is studied as a case here-within based on interview done with the Chairman of Nepal Yarn Producers Association and the founder of mill himself, Mr. Pawan Golyan. About 10,000 employed in four textile yarn industries, of which about 25% are women. Of 4000 employees in Reliance mill, almost 100% blue collar jobs are filled by Nepali citizen. Each year 300 employee leave for foreign employment, so round year training is required to prepare staff. Reliance Spinning mill produces 40,000 ton/ year of which 8000 ton is consumed by nation, rest is exported (Golyan, 2017) .

Reliance spinning mill has also started the production of filament mixed nettle yarns at its factory. These yarns are a blended mix of viscous and nettle fiber at the ratios of 70:30 and 60:40. Reliance spinning mill has not yet commercially produced 100% pure nettle yarn. Thus, this research is noble as it aims to find the process plan for producing 100% pure nettle yarn. Also, the scale of production, size of factory and investment will largely differ when compared to the highly capital-intensive Reliance spinning mill.

2.4 Natural Fiber in Nepal

The textile sector includes manufacturing of readymade garments, yarn, fabric, carpets and apparels of Pashmina, Allo, Hemp and other unique fibers. Textile and yarn are more important for the domestic market, rest are of importance to export market.

Of these, goat's wool or Pashmina and Himalayan Nettle or Allo are very unique to Nepal and popular in the first world countries. Nepal produces around 1,805 tons of Allo each year. Half of the production is consumed within Nepal and the other half is exported (MEDEP, 2010). The specialty of Allo is its strength and durability. As its raw material is found abundantly unutilized in hilly forests of Nepal, yet locals have been harnessing it in limited amount due to very tedious traditional techniques and its demand in national and international market is very high. Prospects of developing Allo fabric as a unique export good seems be very promising.

Table 1 Major Spinning Mills in Nepal

SN	INDUSTRY	PRODUCT DEALT WITH	PROCESS UNDERTAKEN	CAPACITY	LOCATION	REFERENCE
1	JAGDAMBA SPINNING MILLS PVT.LTD	Polyester yarn, polyester viscose blended yarn, and acrylic yarn	Blow room/ Blending Condenser, Carding, Drafting, Roving, Coning, Winding, Spinning	960 MT/ month	Kamariya, VDC-4, Rupandehi, Nepal	(Jagdamba, 2019)
2	RELIANCE SPINNING MILLS LTD.	Polyester/Viscose blended yarn, Acrylic/Polyester blend	Blow room/ Blending Condenser, Carding, Drafting, Roving, Coning, Winding, Spinning	33,480 tonnes/ year	Factory A: Khanar – 12, Itahari, Sunsari, Nepal Factory B: Duhabi Municipality, Sunsari, Nepal	(Reliance, 2019)

2.5 Himalayan Nettle

Genes Species : *Girardinia diversifolia*

Family: Urticaceae

In Nepal, allo (Girardinia diversifolia) is a plentiful plant that grows along rivers and in open forest areas. It normally grows between heights of 1,200m and 3,000m, going from east to west. It is a perennial herb with roots that grows up to 3 meters high, bears shade, and is tall, sturdy, and upright. The leaves are deeply lobed saw-toothed with bristles and have stinging hairs, and the aerial parts are armed with numerous thin stinging hairs. Allo has blooms that are both male and female on the same plant. The stem bark includes strong, silky, and light fibers of a special character. (ANSAB, 2010).

The present study reveals that it is possible to find Allo plant in almost all the hills and mountain areas of the country. Based on local knowledge, judicious subjective decision-making and GIS mapping, 58 districts are found to have Allo production. (MEDEP, 2014)

Pre-proposal research has been done through literature review and talks with the practitioners and experts in the field to gain knowledge and confidence in the field. The extraction process is divided into following activities,

A. Collection of shrubs: The extraction process starts with harvesting of stem of nettle. Best time for collection of shrubs, taking into account the sustainable regeneration of stem is told to be in October to December. By this time, it grows to its maturity and seeds ripe and fall on the ground1. The stout stems are collected and their fiber bearing barks are stripped out. The workers have to be meticulous about it, as they may burn their hands with the stinging hair present in the stem. Chances of mechanizing this, though seems simple, is out of the scope of primary phase of this project.

B. Stripping and drying of bark: The outer part of plants stem is then peeled off. Using sickle or hands, layers rich in fiber are preferentially focused. The inner body is thrown away and the bark is laid down to dry. Some practitioners suggest soaking the stem in water (before drying) for a few days aid to easier extraction. Prospects of using inner bark otherwise left as waste, was found to be high in paper industry.

C. Cooking: The dried barks are then boiled with ash or caustic soda for about 2 hours. The barks are then boiled with ash or caustic soda for about 2 hours. For 8 kg of dry bark, about 1 kg of caustic soda and 4 kg of ash is needed (ANSAB, 2010). To maintain organic qualities, it is recommended not to use caustic soda. And, the process becomes less friendly to workers' health and environment. However, the use of caustic soda reduces cooking phase. The bark is brought to a boil, then let to cool for up-to a day hour.

D. Retting: Retting is a technical name given to breaking down of bark into their component elements and removal of substances which hold the fibers together. Such substances may be dissolved mechanically, microbiologically, chemically or biochemically. In case of the

[1] Practices in Extraction adapted from "Assessment of Allo Production and Enterprise Potential in Parbat District"

indigenous method, it is principally the mechanical means which is involved to a large extent in rural practice. This filters out around 400gm of pectin and hemicellulose from 1 kg of bark.

E. Fiber Separation: After retting, the barks are sun dried again, they almost take their form. As per the prevalent practice, maize flour, rice chaff, limestone or "Kamero" soil is added to the fiber, to make it more lustrous, soft, white and easy to handle. The fibers are intertwined in themselves, so they are separated manually with mechanical means. This process is called carding. The raw fiber is bleached for 20-24 hours in bleaching solution of 200gm of calcium hydroxide and 200gm of sodium bicarbonate in 20 liters water.

F. Spinning and Weaving: After the fibers are extracted, a spinning wheel is employed to produce yarns. The wheel produces strong spools of fiber on rotation. These wheels, also known locally as "Charkha", can be run manually or electrically. Weaving is usually done in handloom or modern machinery. Equal weights of cotton and Allo are used to produce fabric.

2.6 Research on Process Mechanization:

In mid-April 2016, MEDEP-UNDP had called a contest supported engineers to innovate a technology for Allo processing. It resulted into four simplified machines that can be used by entrepreneurs to increase their productivity (MEDEP, 2016). These machines were tested among entrepreneurs at two sites viz, Libang, Rolpa and Salija-7, Parbat and were reported to be very productive. The prospects of these machines were assured to be high by entrepreneurs (Dangi L., 2016). After being tested, this machine setup and the efforts of mechanization were highly appreciated by the Ministry of Industry. "Allo Processing Center" with this machine set was visualized at various pocket districts of Nepal. Extraction process dealt with in the machine layout are:

i. Stripping and Retting (Rolling)

ii. Beating

iii. Hackling (Combing)

iv. Spinning (Advanced Charkha)

i. Stripping and Retting (Rolling)

Rolling, an industrially implemented technique in straining the fiber's source, is used. The pressure due to rolling also disintegrates bark into thinner longitudinal strips. Also, this process helps in squeezing out water from the fiber. This reduces the time for drying in the next phase. The roller's assembly is presented along with:

Figure 1 Picture: Roller being used at site

Features of roller:

- Used in in two steps: Stripping bark i.e., step B. and retting
- Has grooved rollers whose clearance can be changed as per the machine loading needs.
- Takes floor area of about 0.7m x 0.5m

- Needs 1 HP, 220V single phase electric supply
- Additional Comb can be mounted on the roller to refine fiber after retting.

ii. Beating

A rotating crank pin assembly beats the fiber as it oscillates to and fro with wooden planks. A moving platform, upon which fibers are to be longitudinally laid, traverses through the mounted rotating crank pin assembly so that beating is done throughout the length of fiber. A wooden plank attached to oscillating platform continuously beats the bark below it, until the operator assures it is perfectly beaten. The barks take the form of strands by this process. The mechanism is described in the following pictures:

Figure 2 Picture: Beater being used at site

Features of Beater:

- Used in in retting
- All the impact bearing elements (beating head, platform) made of wood for easy rural replaceability.
- Takes floor area of about 2 m x 0.7 m in this first prototype, (scopes of space reduction in second prototype)
- Needs 2 HP, 420V three phase electric supply (scopes of using single phase and power to 1 HP reduction in second prototype)
- Can be used to cast off maize flour/ “Kamero” soil.

iii. Hackling (Combing)

The machine developed for hackling has a revolving drum which has combs in it. These combs gradually open the intertwined stranded into fiber. The bark previously soaked in maize flour and beaten is fed into this machine.

Figure 3 : Entrepreneurs using hackle

Features of Hackle:

- Used in combing
- Has guide/grooves for extraction of fiber from drum.
- Has modular combs in the assembly (easily mounted and detached)
- Has manual feeding system to control machine load
- Required floor area of 1.8m x 1.5m

iv. Spinning (Advanced Charkha)

The Charkha designed is quite different from conventional charkhas as it couples the strands among themselves in parallel as it coils the strands into bobbin. The machine is operated using an electric motor. The operator controls coiling rate using a pulley whose friction can be adjusted.

Figure 4: Charkha being used by an entrepreneur

Features of Charkha:

- Used in spinning
- The bobbin used in the machine is easily available in the form of GI seamless pipes
- Takes floor area of about 1.5 m x 0.7 m in this first prototype,
- Needs 0.5 HP, 220V single phase electric supply
- Rate of coiling can be controlled by changing tension in belt.

Processing phase of nettle is labor-intensive and cumbersome. The source to Allo fiber is robust stinging shrubs that can reach as high as 2m in wild environ. The shrub yields about 600kg in a hectare area, The production process transforms the raw barks of nettle into a fabric at various steps of value addition. Dry bark is marketed at around Nrs. 90/kg, course fiber at Nrs.400/kg and thread at Nrs.600/kg (MoFSC, 2014). Around 40,000 Nepalese are involved in Allo farming across the country. Half of the production is consumed within Nepal and the other half is exported. Based upon state of production, it seems that Nettle lags in terms of volume of production even though it has high prospects of export (ICIMOD, 2015).

2.7 Processing yield

Processing yield is factor to consider while finding the cost of product at various stage. Yield is a measure of quantity of usable or quality end product based against total output. It refers to the percentage of usable produce to the input raw material is usually indicated by the ratio

of the weight of items qualified for further processing or use against the weight of manufactured items. It is usually measured in percentage.

2.8 Allo (Himalayan Nettle) researches in Nepal:

Hereby presented is a list of literature that focuses on Allo production, value chain and its social effects. The first step to jump into the research is to know what has already been done. The review of the documentation relevant to agenda, ones like this, help check the flow of work. The key outcomes of the literature review are the overview declining textile field in Nepal along with their causes from the past, the details of yarn producers in Nepal, prominent fibers exported in the past, advantage of Allo over other options; the existing techniques used to process the raw fiber in home based/ cottage industry which were found insufficient yet could be treated supplementary to an industrial setup.

Table 2 List of published documentation on Nettle in Nepal

SN	Document Name	Research Type	Area under study	Production of Fiber/yarn	Reference
1.	Value Chain Designing of Allo of Panchase Protected Area	Report	Kaski District	NA	(MoFSC, 2014)
2	Traditional Knowledge On Wild Fiber Processing Of Allo In Bhedetar Of Sunsari District, Nepal	Journal Article	Sunsari District	NA	(Deokota, 2009)
3	Promotion of the Allo (Himalayan Nettle) Value Chain in Nepal	Report	Darchula District	20 tons of Allo bark	(Shrestha, 2015)
4	Assessment of Allo Production and Enterprise Potential in Parbat District	Booklet	Parbat District	8.588 tons of dry bark 3.435 tons Allo thread	(ANSAB, 2010)
5	Socio-Ecological Perspectives Of Himalayan Giant Nettle (Girardinia Diversifolia (Link) Friis) In Nepal	Journal Article	Darchula and Sankhuwasabha District	NA	(Subedee, Chaudhary, & Upreti, 2018)
6.	Understanding The Role Of Women Home-Based Workers In Value Chains Of Large Cardamom And Allo In Nepal	Report	Sankhuwasabha District	NA	(WORLD BANK, 2019)
7	Value Chain Analysis Of Selected Forest Based Products Of Rapti Area	Journal Article	Sunsari District	Approx. 150 tons of bark	(Poudel & Pyakurel, 2014)

8	Transforming the Lives of Mountain Women Through the Himalayan Nettle Value Chain: A Case Study From Darchula, Far West Nepal	Report	Darchula District	20 tons of Allo bark	(Shrestha, 2015)
9	Assessment of Allo Production and Enterprise Potential in Parbat District	Journal Article	Darchula District	20 tons of Allo bark produced	(Adhikari & Shrestha, 2018)
10.	Value Chain Analysis of Forest Products in Koshi Hill Districts of Nepal:	Report	Koshi Hill District	NA	(Rai & Chapagain, 2014)
11	Value Chain Analysis Of Selected Forest Based Products Of Rapti Area	Journal Article	Sunsari District	Approx. 150 tons of bark	(Poudel & Pyakurel, 2014)
12	Transforming the Lives of Mountain Women Through the Himalayan Nettle Value Chain: A Case Study From Darc hula, Far West Nepal	Report	Darchula District	20 tons of Allo bark	(Shrestha, 2015)
13	Assessment of Allo Production and Enterprise Potential in Parbat District	Journal Article	Darchula District	20 tons of Allo bark produced	(Adhikari & Shrestha, 2018)

Apart from these literature, Value Chain Based Approach to Micro-Enterprise Development: Value Chain Analysis-Allo" discusses the presence of Allo in national context in a holistic approach. Of the 1805 tons of Allo yarns produced in Nepal, (MEDEP, 2014), major shares of produce are seen to be found in specific hilly districts.

The comprehensive MEDEP study suggested a large potential as “50 of 70 districts in Nepal have Allo growing naturally”. Other studies have focused on specific regions or districts -

ANSAB (2010) on Parbat district, UNDP (2014) on the Rapti area, NFA (2014) on Rolpa, Baglung, Nuwakot, Dolkha, and Sankhuwasabha districts, Lamichhane (2016) on the Myagdi district, according to Adhikari et.al (2018). The existing techniques have been able to produce 1805ton Nettle /year, but the output is either handmade or inconsistent thread and fabric.

From literature, fiber diameter mean values 30–35micrometer were comparable to those of the elementary fibers of hemp 32–34 micrometer (Kundu, 1942) and flax (20–30 micrometer), while fiber length mean values (48–52 mm) were higher ,hemp: 20–28 mm; (Hoffmann, 1957); flax: 20–30 mm (Bacci, 2008) . So, Nettle (Allo) can be defined as short staple fiber. Processing of short staple fiber must be considered in processing Allo.

2.9 Processing of Short staple fiber:

Two different fiber-preparation systems majorly used: the woolen system and the worsted system. The system chosen depends largely on the length of the staple and the properties required in the end product. Figure above summarizes the stages that occur in the two systems. The woolen system is generally used for shorter fibers, although a wide range of wool types can be prepared in this way. It is also necessary to distinguish between the terms ‘woolen yarn’, which usually refers to a 100% wool yarn, and ‘woolen-spun yarn’, which refers to a yarn spun on the woolen system but that contains other fibers.

However, because of the wide range of raw materials processed using this system, the exact sequence of machines used by individual manufacturers varies widely.

The researches on possibilities of spinning have already been done by two independent research teams in India:

1 This paper deals with the use of enzymes for the extraction of fibers from Girardina Diversifolia, the Himalayan Nettle plant bark obtained from Uttarakhand, India. The fibers have been bio scoured and bio softened and blended with organic cotton/ bamboo (nettle: organic cotton and nettle: bamboo in the ratio 50:50) to make it suitable for open end spinning. (Radhakrishnan, 2015)

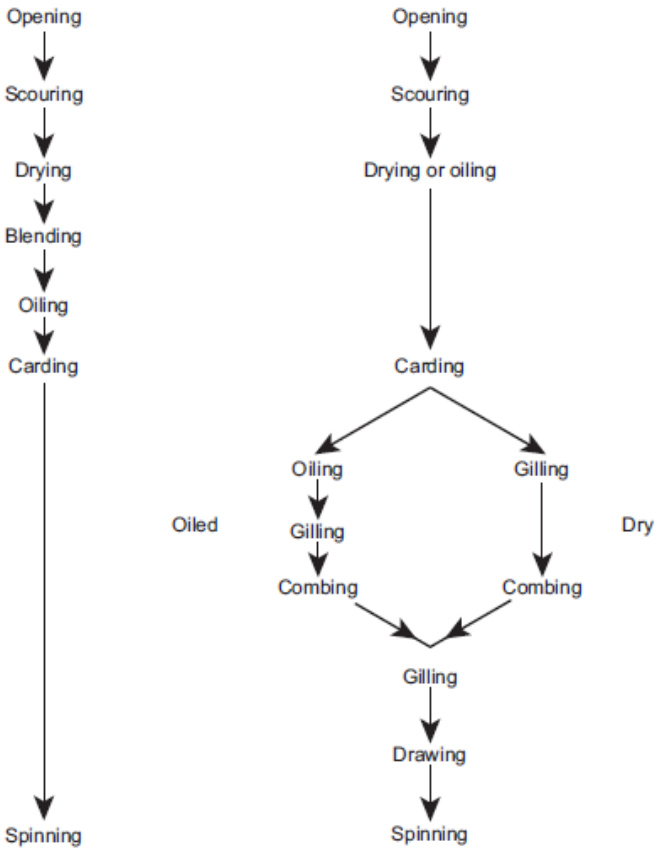


Figure 5 Woolen (left) and worsted (right) systems (Elhawary, 2015)

2. In this paper (Sett, Ray, & Mukherjee, 2014), attempts have been made to explore the possibilities of spinning textile grade yarn using Himalayan Nettle. Physical properties of nettle fiber are tested and found to be suitable for spinning. Initial attempts were made to open the fibers from the available reeds and processed through modified cotton spinning (miniature) system with and without blends. 140 tex pure yarn and 60 tex blended (N:V) =87.5:12.5 % was spun using this technique at a spindle speed of 7,000 rpm in conventional ring frame. Properties show suitability of this yarn for wide range of textile products from apparel to technical textiles.

2.10 Power and energy for a textile industry

In a textile industry, energy cost stands in second position in the list of costs after raw material cost. Energy cost is about 15% - 20% above production cost (Y. Dhayaneswaran, 2013). Breaking down the energy usage into sub-sectors can help visualize the major power governing areas. Energy distribution in a textile mill is studied based on the leading textile

mill of Tamilnadu, India. A typical cotton textile mill differs from Allo mill in terms procedure of extraction and production revenue, but the consumption share may give the idea of textile mill.

Figure 6 Drafting and Spinning of mixed Nettle fiber in Lab (Radhakrishnan, 2015)

Ring spinning takes about one half of total power in the plant, so feeding thread into bobbin is the most energy intensive task. Preparatory processes like blow room, carding etc. removes impurities and prepares raw fiber for further processing stands second in the list of energy intensive process, humidification unit and autoconer are the third and fourth processes. These processes have to be analyzed in the plant to find any scopes of improvement of energy usage and efficiency. The energy efficiency of the plant can be judged based on a series of audits and analysis of data collected from the plant.

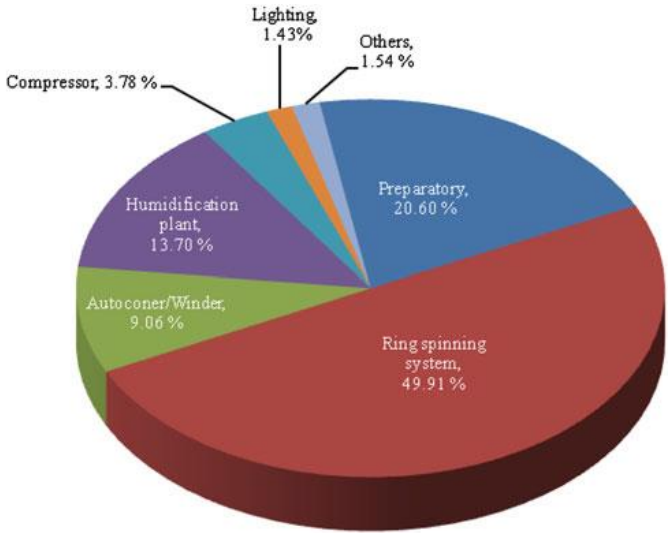


Figure 7 Power distribution in textile mills including productive (Y. Dhayaneswaran, 2013)

2.11 Capital Structure, Expenses, Revenue and Financial Feasibility:

Capital structure is the particular combination of debt and equity used by a company to finance its overall operations and growth. Equity capital arises from ownership shares in a company and claims to its future cash flows and profits. Debt comes in the form of bond issues or loans, while equity may come in the form of common stock, preferred stock, or retained earnings. Short-term debt is also considered to be part of the capital structure.

Expense refers to the total cost required to manufacture goods. This concept is the basis for several cost accounting analyses. Expense have traditionally been broken down into the following three categories of cost:

Direct Materials

Direct materials are the cost of those materials directly associated with the production of goods. It can also include the cost of materials destroyed during the setup and testing of production equipment, as well as scrap.

Direct Labor

Direct labor is the cost of labor directly associated with the production of goods. This category of cost has been called into question, since most production labor is actually needed

to provide a minimal level of staffing to the production area, and so should really be considered an overhead cost. Only in cases where labor costs can be specifically associated with a particular unit of production should costs be considered direct labor.

Manufacturing Overhead

The manufacturing overhead category is comprised of all the costs incurred that are needed to run a factory, but which are not associated with a specific unit of inventory. Manufacturing overhead can include, but is not limited to, equipment depreciation, equipment maintenance, factory rent, factory utilities, materials handling staff wages, production supplies, quality assurance staff wages, and supervisor salaries.

Upon calculating all the expense, deducing it from revenue, subjecting it to the taxation policy, one can create the cash flow diagram which is crucial to studying project feasibility. Then tools like net present value method and internal rate of return method can be used to understand the breakeven of the project and its profitability.

Net present value (NPV) is the difference between the present value of cash inflows and the present value of cash outflows over a period of time. By contrast, the internal rate of return (IRR) is a calculation used to estimate the profitability of potential investments.

Both of these measurements are primarily used in capital budgeting, the process by which companies determine whether a new investment or expansion opportunity is worthwhile. Given an investment opportunity, a firm needs to decide whether undertaking the investment will generate net economic profits or losses for the company.

2.12 Conventions of Value Addition:

Th Value Addition is the difference between the final selling price of a product and the cost of the intermediate inputs used to produce it. There are five conventions of value added that are often discussed in economic analysis:

a. Production Convention: This convention focuses on the value added by each stage of production. It calculates the value added by subtracting the cost of intermediate inputs (raw materials, components, etc.) from the total value of output produced. This helps

in understanding the contribution of different stages of production to the overall value added.

b. Income Convention: The income convention looks at value added from the perspective of income generated for factors of production. It calculates value added as the sum of compensation to labour, taxes (minus subsidies) on production and imports, and gross operating surplus (profits) of businesses. This convention highlights the distribution of income among different factors of production.

c. Expenditure Convention: The expenditure convention considers value added in terms of final consumption expenditures. It calculates value added by subtracting the value of imports used in production from the total expenditure on final consumption. This approach is used in the context of calculating gross domestic product (GDP) by the expenditure method.

d. Value Added Tax (VAT) Convention: This convention is particularly relevant in the context of taxation. It calculates the value added at each stage of production by subtracting the value of intermediate inputs from the sales revenue. The VAT paid at each stage is based on the value added, ensuring that taxation reflects only the value added at that stage.

e. Trade Convention: The trade convention calculates value added by taking into account the value of exports and imports. It considers the difference between the value of exports and the value of imports to determine the net value added in a country's trade activities.

These conventions provide different perspectives on how value added is calculated and understood within economic analysis.

CHAPTER THREE: METHODOLOGY

Following stages were incorporated in research phase:

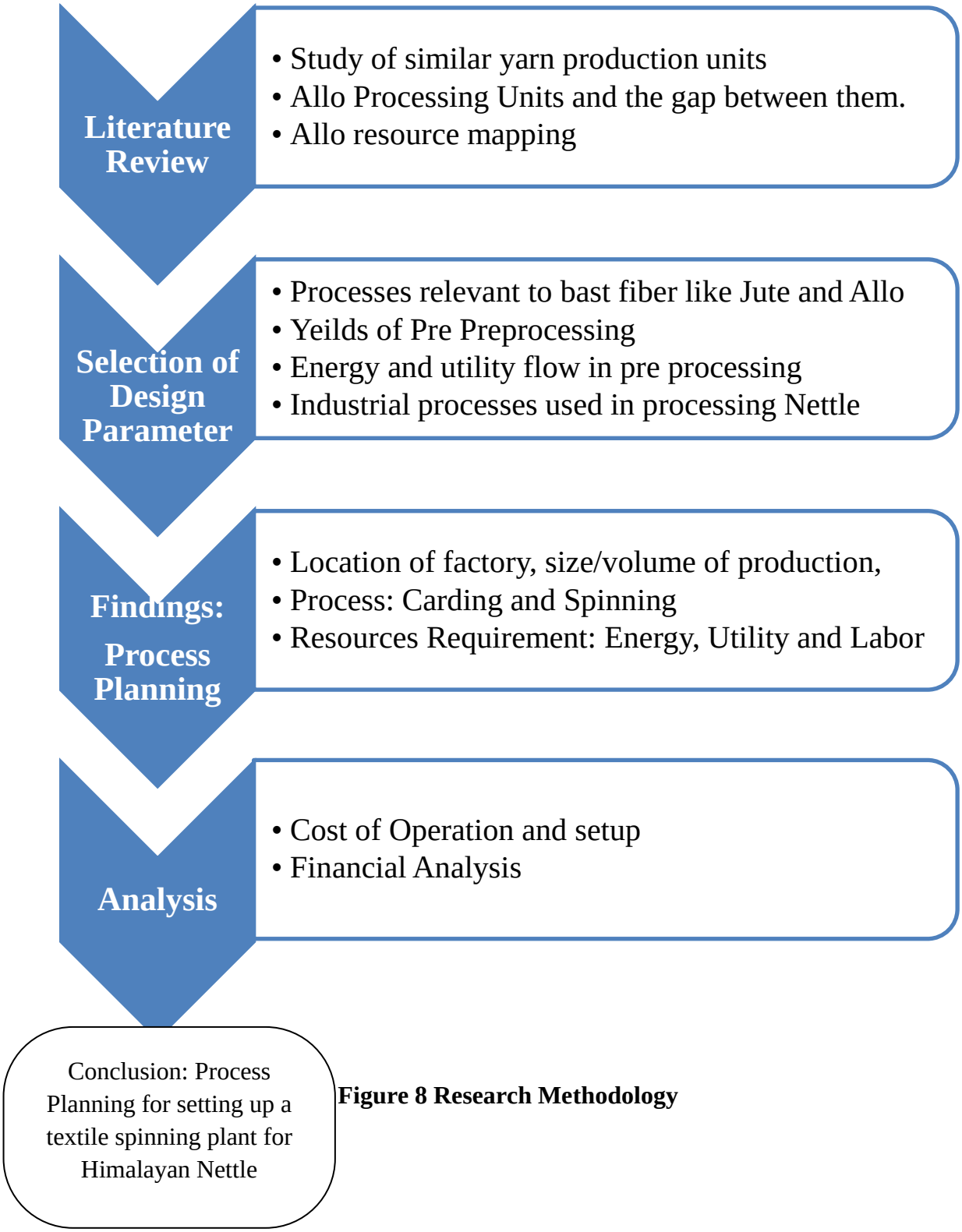


Figure 8 Research Methodology

3.1 Stages Of Textile Processing for Bast Fiber

Literature review presented in previous chapter of the report suggested the basic layout of production processes for long staple fiber like wool. This section will only discuss the processes that have relevance to the activities accounting design phase.

Fiber material is either grown in agriculture (animals and plants) as renewable resources or gained from fossil resources (crude oil). Whereas natural fibers have to be harvested and prepared for yarn formation (spinning), man-made fibers have to be chemically extracted from crude oil fractions or other natural resources before they can be spun. Consequently, spinning processes for natural fibers show significant differences compared to spinning operations in man-made fiber production. For this research, focus will be given in extraction from natural bast fiber, Nettle.

The next step is the conversion of the one-dimensional material (yarn) into a two-dimensional material (fabric), achieved mainly by weaving or knitting in a mill. Non-woven fabrics may also be found in linings of apparel, but their main application is in automotive interiors, disposables and technical textiles. In dyeing and finishing, a variety of processes, specifically adapted to the raw material and the desired properties, are carried out. The main sections are pretreatment (cleaning and preparation), dyeing or printing, and finishing, where surface properties of fabrics are treated. Spinning, weaving/ knitting and finishing are often carried out in individual companies, which are highly specialized in the individual processes. However, some companies are integrated as they are equipped for all processes. Like in Nepalese industries, Spinning Mills specializes only in producing yarns from raw fiber (Golyan, 2017) while, Shree Raghupati Jute Mill and Birat Jute mill produce fabric from retted jute provided by farmers (Balfour, 1990).

A staple-spun yarn is a linear assembly of fibers, usually held together by the insertion of twist, to form a continuous strand that is smaller in cross-section but of a particular specified length. It is used for making fabrics in processes such as knitting, weaving and sewing. The amount of strength or the quality of handle and appearance will depend on the way the fibers are assembled in the yarn system (Eric, 1987; Klein, 1995). The fibers can be natural or man-made. Man-made staple-fiber yarns are manufactured by using staple fiber cut from continuous filament before spinning. Staple-fiber yarns can be subdivided and classified on

the basis of fiber length, spinning method and yarn construction. Each of these categories can be further subdivided.

Staple-spun yarn can be classified as either short staple or long staple. A staple fiber has a length of between 100-500 mm. Short staple fiber has a maximum length of 60 mm (cotton fiber is a short staple at about 25–45 mm). Long staple fiber has a length of more than 60 mm (wool fiber is a long staple at about 60–150 mm). So, Nettle (Allo) can be treated as a short staple fiber. Processing of short staple fiber must be considered in processing Allo.

To summarize there are many processes to be undergone while textile processing depending upon source of material and character of yarn and garments needed. Jute, wool, nettle, though there are specific addition to be done for each these plant fibers, the following processes are common to most of the long bast fibers:

Table 3 Processes relevant to Nettle spinning

Process	**Function**	**Input**	**Output**
*Opening	Debarking, Retting, Drying	Raw Source of fiber	Retted fiber
*Scouring	Cooking in NaOH or fly ash and beating	Retted Fiber	Opened long fiber, intertwined with impurities
*Drying/Hackle	Sun drying with white mica clay	Intertwined fiber	Thoroughly separated staple fiber
**Blending (If needed)	Add additional foreign fiber to Change the character of yarn	Separated fiber cut into smaller strands	Weaker fiber yet quality changed due to doping
***Carding	Open up/disentangle the fibers and removes dirt and vegetable matter	Pure or Blended fiber	Carded fiber, ready to be drafted/gilled and spined
Drawing/Roving	Stretches out the slivers to reduce their linear density or thickness	Sliver	Lightly Twisted thread
Spinning	Adds twists and spins it into the bobbin	Twisted thread	To Yarn Spools

*The processes Opening, Scouring, Drying, Hackle is customized as per the traditional techniques of Nettle Processing.

** Blending is not required if making pure nettle yarns as it depreciates the strength of Nettle fiber, while, it is preferred only when softer textiles are to be produce at the cost of its strength.

***The exact specification of the woollen card and combing requirement will vary according to the types of fibres that will be processed and the range of yarn linear densities required.

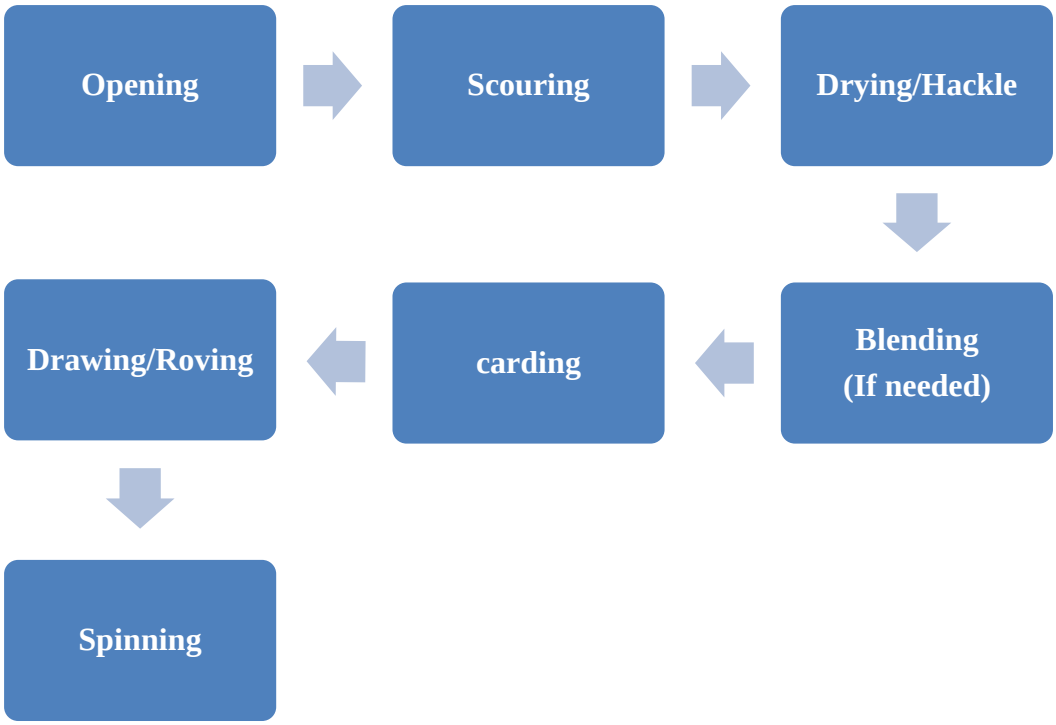


Figure 9 Processes for Nettle yarn production

3.2 Pre-processing of Bast Fibers

Bast fibers are the source of the plant source fiber, particularly extracted from the bark of plant. Flax (source of Linen), Hemp, Jute, Kenaf, Nettle etc. are example of fiber extracted from bark. Of all, Nettle being of our interest, needs to be preprocessed before standard industrial processes can be exercised. Pre-processing is important as it is impractical to start from stem of the plant. For this, Jute processing model is considered to be applicable, where-in the farmers can harvest their stem, debark it, ret it in ways most practical to them, cook them, scour them, hackle them then finally send them to the industry. This would produce some social benefits.

The machines and techniques discussed in chapter 2 are best suited for home-based industry, so they can be used to produce raw fiber in local level, but yarn production can only be

industrialized if all these output from home-based industries could be fed into a central industrial production line. This will render many benefits.

a. The production bottleneck when producing yarn with hand tools has never made it sustainable, so if home based and small industries could only prepare abundant raw fiber, the central industrial production line can take it from there, to produce yarn, fabric and other products. This way both grass rooted enterprises that produce raw fiber and central industrial setup can symbiotically succeed.

b. The national dependence to imported fiber/yarn to produce in house garment can be substituted.

c. The production capabilities will be uplifted at national level if the nettle farming/processing were promoted at otherwise underutilized hilly districts of Nepal.

d. Nettle is very unique to Nepal, as it is not popularly found in other Asian nation, but its popularity in first world is prominent, thus it can be branded and presented like other renowned products like Pashmina, Hemp, Lokta Handmade paper, Felt, Gorkhali Khukuri, etc.

Thus, this thesis divides total production processes of Nettle Yarn into Preprocessing and Processing phases, where in the preprocessing will be done by smaller home-based entrepreneurial group to produce raw fiber. This raw fiber will be input to industrial setup being designed under this research.

3.3 Experimentation: Yield at various preprocessing steps:

After literature review, an intuitive picture of production layout can be sketched. But specifically, when considering Nettle, this production layout would be imaginary if the feasibility of inputting raw fibers from home based / cottage industries into industrial spinning setup is tested. That is, following the jute collection model usually practiced by Jute mills, Allo that has been preprocessed (Opened or Debarked, Scoured or Retted, Dried and Hackled) from Home based/ Cottage industry has to be effectively and efficiently consumed in the processing units (Blending, Carding, Gilling/Combing, Drawing/Roving Spinning) of

the proposed industrial setup. Thus, pre-processing of bark has been tested as per the prevalent techniques.

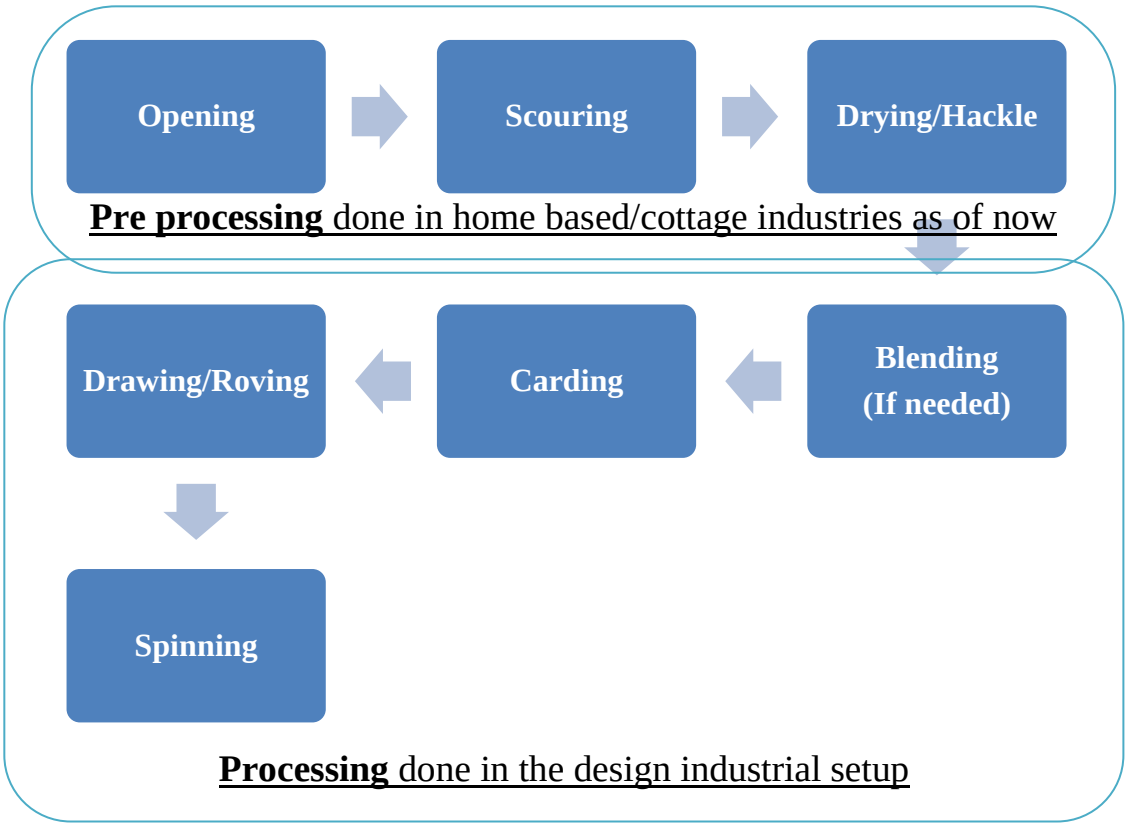


Figure 10 Preprocessing phases and Industrial Process

Processing Test:

18 kg of dried barks (6month old harvest) was obtained from Parbat district for experimentation of yields at various steps of pre-processing. 6 Batches of 3kg dried bark were divided to perform experiment 6 times. The controlled temperature of 80-85 degrees was set manually by tuning a LPG burner, three different NaOH concentrations was used in 3 different batches combined with three different cooking time. Results were compared after thorough washing until removal of NaOH and finally spun dried at 500 rpm for 5 min and sun dried for a day to remove all absorbed water. Finally, a cooking process is estimated using industrial cooking vessel to anticipate the bulk cost cooking in an industrial setup. Cooking Vessel considered for this industrial process is a 3 Phase 9 KW PID Controlled 200 ltrs double jacketed SS Cooking vessel industrially available for this process.

After cooking, total obtained fiber was divided into 6 batch of 2.8kg (totaling kg 16.88 previously cooked output) and machine beaten for 10 min each with repeated rinsing. Again, the beaten fibers were spun dried at 500 rpm for 2 min.

Beaten fiber was soaked in maize flour slurry and sun dried for a day. The sun-dried fiber was then combed to open the intertwine using hackling process.

The hackled yarn was later converted into roves such that 0.1kg fiber hackled was separated and manually divided into 100 roving each 1m long using a rove hole as in the picture. These roves will be used in manually spinning the yarn of Metric count 1. There was no loss of fiber in this process as all the fiber was converted.

Output yields of fiber at each experiment were noted. Energy cost, bulk labor cost and utility cost (cost of water, chemicals etc.) for all four activities were logged. Processing cost per kg at different stages was calculated to identify the value added at different stages along with the percentage yields were calculated at each stage to calculate the total extractable fiber from 1 kg of raw bark.

Figure 11 Fibers before beating and after hackling steps of pre-production

Figure 12 Hand spun nettle yarn

3.4 Process Parameters for Carding

The plant is designed such that pure Nettle thread is produced in yarn from raw fiber, so no blending process is incorporated into this research. For this the preprocessed fiber can be should undergo:

3.4.1 Carding

Nettle tow from hackling is passed through a carding process. The tow is finer and shorter from each succeeding process prior to carding. Usually for bast fiber like Jute and Linen which represents the nettle in terms of fiber quality, a combined breaker-finisher carding setup can be used to card nettle like flax.

The roller arrangement of a breaker-finisher card is shown in figure above. This particular machine arrangement is described as a down-striking, seven pair, full-circular card with double doffers. The fibers, after feeding, are carded by a series of pairs of pinned rollers called workers and strippers. The roller arrangement of a breaker-finisher card is shown in figure. This particular machine arrangement is described as a down-striking, seven pair, full-circular card with double doffers. This means that the cylinder pins move downwards at the point of feed, there are seven sets of workers and strippers (in addition to the feed stripper), the full circumference of the cylinder is utilized, with the two doffers which are used to remove the fibers from the cylinder mounted above the feed point.

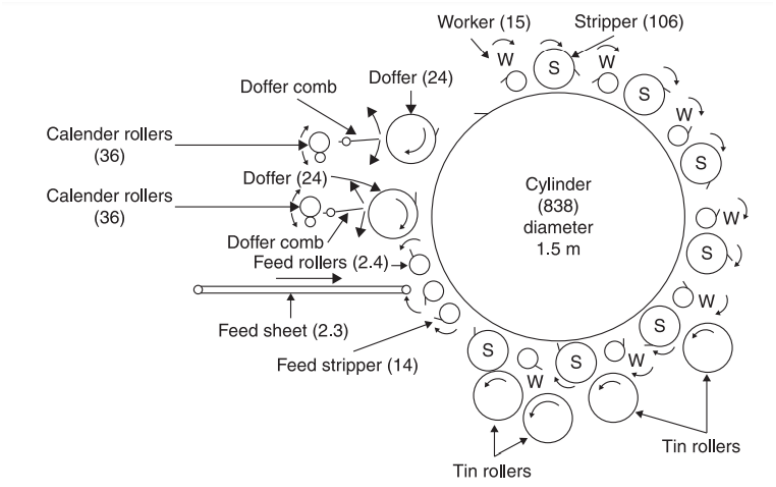


Figure 9 A typical breaker finisher carding machine

The tin rollers mounted with the first three sets of workers and strippers underneath the cylinder help the strippers to pick up long fibers which otherwise might be lost. The web of fibers removed by each doffer is divided into three equal widths to form three slivers, each about 75 mm wide. The corresponding slivers from the top and bottom delivery rollers are combined and the three slivers thus formed are doubled to feed a roller drafting drawing head with a draft of about 2, before being delivered into a can as a single sliver of about 6 to 12 ktex (Oxtoby, 1987).

3.4.2 Drafting:

It consists of passing a continuous assembly of fibers between relatively slowly rotating back rollers, and then between a pair of front rollers running at a higher surface speed. It is characterized by

Draft = Input linear density/ Output linear density

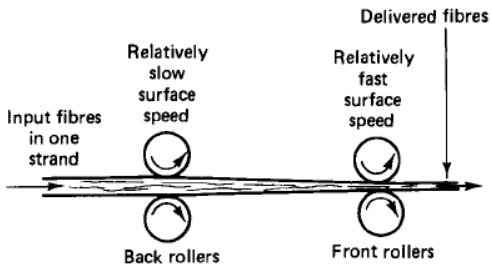


Figure 10 Illustration of Drafting process

Doubling is the feeding of two or more fiber assemblies simultaneously into a drafting zone so that they are combined together and delivered as one fiber assembly, the purpose being to promote regularity and fiber mixing. (Wira, 1949)

It is possible to produce either carded or combed quality yarns from flax tow. For the carded quality, drawing consists of a machine arrangement similar to that shown below, but with shorter ratches, and producing a and producing a thicker roving.

3.4.3 Spinning

Rove is spun into yarn via wet ring spinning, which is slower and more expensive than two other common spinning techniques (open end rotor spinning and vortex spinning). However, to this date ring spinning seems to be the only technique that yields pure bast fiber yarns of sufficient quality for apparel textile applications. Wet spun yarn must be dried after spinning. This step is carried out in a hot air dryer. Finally, the yarn from small “cops” (spinning bobbins) is wound on bigger cones for retailing. The winding machine also checks and removes the defects of the yarn.

The hackled fiber will further be cut into appropriate length for carding. Based on literature reviews, woolen method requires cutting natural fiber into lengths of 40-50mm. Thus, the hackled fibers will be cut and fed into a woolen carder to straighten the fiber into roves.

3.5 Location, capacity and scale of the industrial setup

Based on secondary data from reports published, the presence of micro-entrepreneurs’ group will be analyzed. This helps in identifying sources for pre-processed material. Also, the data for availability of raw material will be used to identify the most feasible cluster district for production of Nettle yarn. Based on the maximum availability of nettle fiber, access to electricity and the size of existing market, the location and size of production will be chosen such that this industrial facility can process the raw material available in the region. The yield of various preprocessing steps will be used to estimate the maximum availability of hackled nettle thereby finding the limiting production capacity of the location. Under this limiting production capacity, the production capacity of the plant will be set.

CHAPTER FOUR: FINDINGS AND DISCUSSIONS:

4.1 Yields of Various Pre-processing stages:

As no literature and documentation was available that confirmed the output of preprocessing steps of nettle processing, the experiment setup was designed to study the process parameters of cooking, beating, hackling and manual spinning. The table in the next page compiles all the findings of the experiment.

Cooking

Six Batches of 3kg dried bark were divided to perform experiment 6 times. The temperature was read and maintained by a PT 100 temperature sensor to 80-85 degrees. The temperature was set manually by tuning a LPG burner, three different NaOH concentrations was used in 3 different batches combined with three different cooking time. Results were compared after thorough washing until removal of NaOH and finally spun dried at 500 rpm for 5 min and sun dried for a day to remove all absorbed water.

The yield of fiber was gradually reduced as the concentration of NaOH increased from 2-4 %, but the degumming process was gradually effective until 4% concentration. Also, ass the time of exposure was increased from 120mins to 240 min the yield reduced but the darker color nodes and barks that were connected with the fiber inside subsequently separated as the cooking time increased and almost saturated at the values of 5% NaOH and 240 minutes cooking time. So, the best outputs recorded at 4% NaOH concentration at 240 minutes exposure. The lowest yield of 90.13% for this cooking setup produced the best fiber separation outputs. Further increase in time and concentration did not significantly change the results.

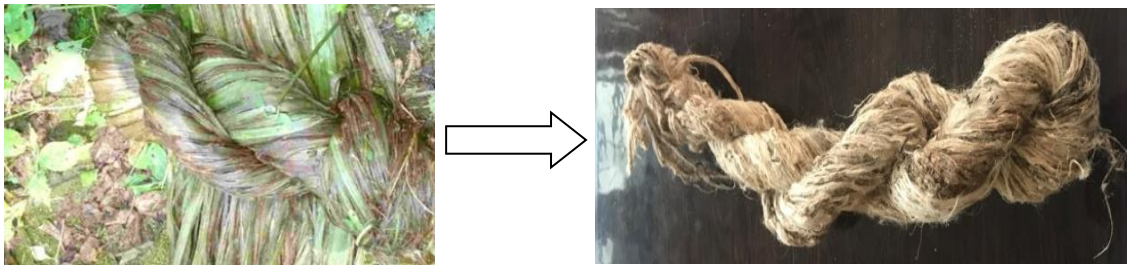


Figure 11 Uncooked vs Bark cooked in 4% NaOH for 3 hours

Beating Process

Total fiber produced from 6 batches of cooking was found to be 16.95kg. This was beaten in 6 batches for 10 min each under the beating machine discussed in chapter 2. With repeated water rinsing and finally spun dried at 500 rpm for 2 min and sun dried for a day, the total fiber yield of beating process was also noted to be 66.98%. There is about 31% loss in fiber weight after beating and major residual bark was removed from it.

Hackling

Next in the process, the sun-dried fiber after beating was submersed into maize slurry in the ratio 1kg/10ltr maize in water as per literatures, sun dried for a day and hackled 12kg dry fiber in batch of 1 kg for 3 mins each. This process removed shorter fibers and any intertwining knots in the fiber was removed. About 10% fiber was lost in hackling. The fiber came out separated and a lustrous quality was added. The fiber seemed clean and free from the barks, ready to be treated as wool or jute in terms of quality and texture.

Spinning on a Charkha

The hackled fiber was pulled into untwisted roves and manually spun into yarns. A 100 gm hackled fiber was pulled into 100 m rove to create the yarn of 1 Metric count. No loss of fiber occurs in this process, yet only 250 m yarn was spun in one man day, thus making it very labor intensive.

The aggregate yield of all 4 steps of pre-processing can be calculated by multiplying lowest yield of each step. The aggregate yield of fiber come to be 54.58 % meaning upon processing of 100kg dry bark only 54.58 kg pure fiber can be retrieved.

4.2 Costs of Various Pre-processing stages:

The cooking process in smaller batch demonstrated the percentage yield of fiber against the removal of binding material in the bark. But, considering the energy in the process, the energy consumed by weighing the change in weight of LPG cylinders. As the cost of cooking smaller batches will be mis guiding for estimating the bulk cost of cooking, this cooking process cost is estimated using industrial cooking vessel. Cooking Vessel considered for this industrial process is a 3 Phase 9 KW PID Controlled 200 ltrs double jacketed SS Cooking vessel industrially available for this process.

Utility cost included the cost of water supply taken as highest unit tariff defined by (Rajit Ojha, 2018) at Nrs 37/CuM. The cost of Caustic soda pallets as purchased locally was Nrs. 300/kg and that for maize floor was Nrs 110/kg. The cost of skilled labor of Nrs 1200 per man day. In table 4, these costs have been fed to all the activities done in preprocessing experiment results to find the cost in each pre-processing steps. Finally, the table 5 below presents the total processing cost in bulk cooking, beating, hackling and manual spinning.

Table 5 Cost of Manual processing (Nrs/kg)

SN	Material and process	Cost of Processing (Nrs/ kg)	Cumulative cost (Nrs/kg)
1	Dried nettle bark	205	205
2	Bulk Cooking	125.89	330.89
3	Beating	23.61	354.50
4	Hackling	30.45	384.96
5	Manual Spinning	3502	3886.96

The above table emphasizes that manual spinning process used in status quo has multiplied the cost of yarns by 10-fold to up to Nrs 3887/kg. This cost is at least thrice the maximum retail price of imported nettle yarns. Thus, manual spinning being labor intensive process has made in impractical to produce nettle yarn rurally in Nepal. This thesis aims to develop a separate spinning unit that intakes the hackled fiber from the producers and spin yarns using industrial technique to reduce the cost of production.

Table 4: Yields of various preprocessing stages and their unit processing costs

SN	Pre-processing	Input	Controlled condition	Change 1	Change 2	Input Weight (kg)	Final Weight (kg)	% yield from dried bark	Energy	Energy Cost Nrs	Utility cost	Bulk Labor cost	Cost PER KG
1	Cooking and Washing	Dried Bark of Nettle	80-85 degrees gently heated on SS vessel, Change 1: NaOH concentrations Change 2: Different cooking times Thorough washed and drying spun	2%	120	3.08	2.96	**96.10**	**0.35kg of LPG i.e., 16.1 MJ**	40	72.42	225	
				4%	120	3	2.8	**93.33**	**0.3kg of LPG i.e., 13.8 Mj**	34.28	144.42	225	
				2%	180	3.04	2.88	**94.74**	**0.46 kg of LPG i.e., 19.1 Mj**	52.57	72.42	450	
				4%	180	3	2.77	**92.33**	**0.42kg of LPG i.e., 19.32 MJ**	48	144.42	450	
				4%	240	3.04	2.74	**90.13**	**0.595kg of LPG i.e., 27.37 MJ**	67.42	144.42	600	

			dried at 500 rpm for 2 min And sun dried for 1 day	5%	240	3	2.74	**91.33**	**0.52kg of LPG i.e., 23.9 MJ**	59.42	180.42	600	
1a	Industrial Cooking Estimate		85 deg cooked at 4% NaOH for 3 hours in Double jacketed SS agitated vessel	4%	240	40	36	**90.00**	**Total 18 units electricity in 4 hours**	216	2407	600	125.8984
2	Beating	Washed fiber	Made 6 batches of 16.95 kg output and beaten for 10 min each with repeated rinsing with 165 ltrs water and finally spun dried at 500 rpm for 2 min		60	16.95	11.3	**66.98**	**1.5 KW for 1 hour = 1.5kwhr = 1.5 units**	18	1.68	225	23.61
3	Hackle	Sun dried fiber	Made slurry of fiber 1kg/10ltr maize in maize floor, sun dried for a day and hackled 12kg dry		60	12.3	11.16	**90.50**	**0.75 Kw for 36 min = 0.45**	5.4	100.35	225	30.45

			fiber in batch of 1 kg for 5 mins each					**KWhr= 0.45 units**				
4	Manual Spinning process with Charkha	Hackled Fiber	0.3kg fiber hackled was separated and manually divided into 300 roving each 1m long sliver/roving then fed to a Charkha manually to spin yarn	410	0.3	0.3	**100.00**	**0.375 Kw for 6.8 hours**	30.6	0	1020	3502

4.3 Resource Allocation and Size of Production

4.3.1 Location

Based on Data from MEDEP, the presence of micro-entrepreneurs' group is considered to make sure supply of pre-processed material is not a problem. The data (Annex 1) considered is the presence of Allo enterprises in 15 hilly districts under consideration.

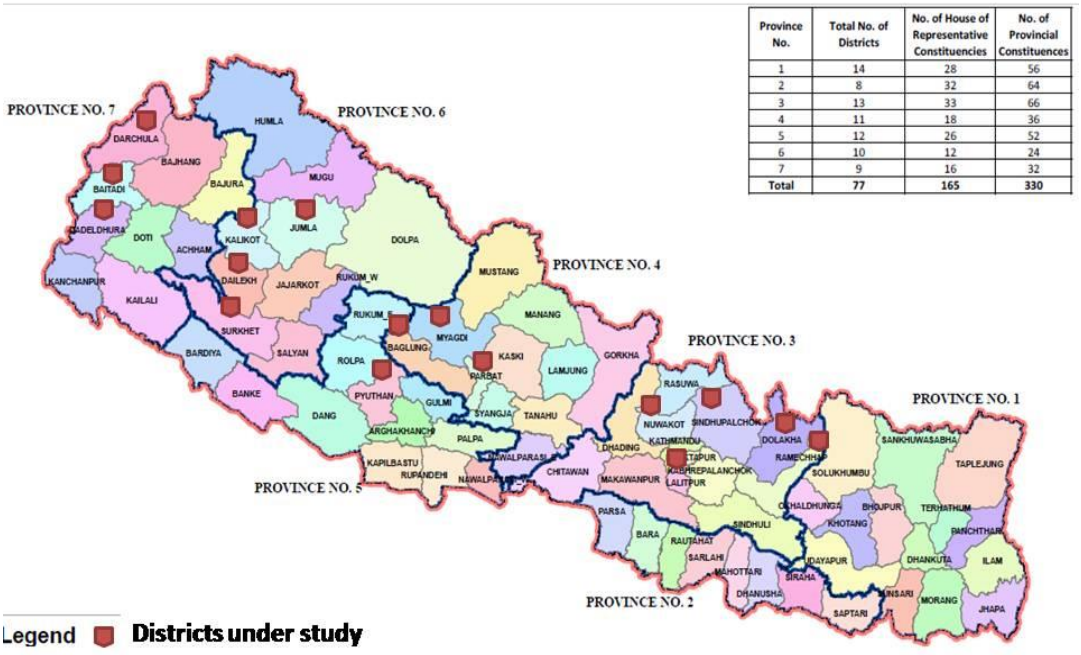


Figure 12 Nettle Producing Districts under study

More over if we clustered these study districts, the following four clusters can be seen as in map of Nepal. Four clusters can be identified vividly and the cluster consisting Myagdi, Baglung, Pyuthan and Parbat have the highest yarn production capacity of 14000kg.

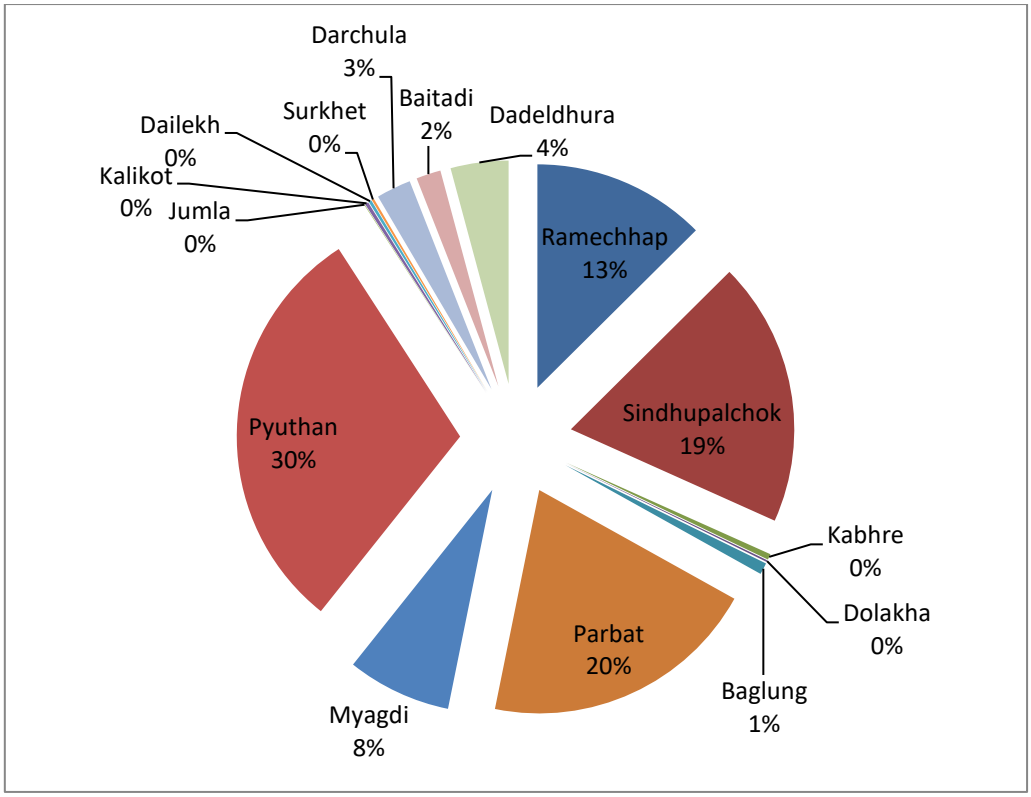


Figure 13 Spread of Yarn Production among studied district

To consider the most cost-effective district for raw material transport, the following approach was taken:

- The distances and time taken to navigate from one district headquarter to another district headquarter was extracted from Google Maps. The distances are tabulated under Annex: Data for inter district distances between the considered districts and Annex: Data for time taken to travel between various districts and the considered district.
- Data of Potential harvest from each district was considered as the weightage for calculation of a cost parameter
- District with the minimum cost parameter will be chosen for factory location

Cost parameter is an indicator defined for the purpose of choosing the district which will have the most cost-effective location for transport of raw material. Cost parameter for each district takes into account the total distance the weight needs to move in transporting raw

material from all the rest district and total time the weight need to move on the road while collecting the material.

$$Cost\ parameter\ for\ each\ district = \frac{\sum Potential\ harvest\ of\ district\ x\ distance\ from\ this\ district\ to\ other\ district}{\sum distance\ from\ this\ district\ to\ other\ district} \text{ x } \frac{\sum Potential\ harvest\ of\ district\ x\ time\ taken\ to\ travel\ from\ this\ district\ to\ other\ district}{\sum Time\ taken\ to\ travel\ from\ this\ district\ to\ all\ the\ rest\ district}$$

Also, the data of size of existing market (in kg of yarn produced) has been used as an indicator of access to market of yarn. The access of electricity (Directorate, 2021) has also been used to identify the ease of access of electricity amongst the best performing districts.

Province	Districts	Cost Parameter	Market size (kg of yarn)	Access to electricity %	Potential Harvest (Ton)	Cluster Capacity (kg)
3	Ramechhap	1306.654	3,000	99.23	0	7,705
	Sindhupalchok	1265.395	4,575	95.26	10	
	Kabhre	1236.073	100	89.55	35	
	Dolakha	1296.285	30	99.52	20	
4	Baglung	759.4287	200	90	**55**	**14,000**
	Parbat	760.784	4,800	91	40	
	Myagdi	761.4373	1,800	92.35	73	
5	Pyuthan	731.2292	7,200	94	70	
6	Jumla	956.9517	10	19.3	55	160
	Kalikot	948.8683	60	43.57	36	
	Dailekh	892.8958	50	48.73	65	
	Surkhet	885.8824	40	48.1	20	
7	Darchula	1269.38	600	40.58	22	2,025
	Baitadi	1257.374	425	34.36	0	
	Dadeldhura	1219.288	1,000	79.84	13	

Table 4.1 District wise comparison of Cost parameter.

The districts have been chosen based on a multi criteria decision analysis (MCDA) with weighted sum method. Four decision variables are under study. Cost parameter, Market Size

(kg of Yarn) , Access to electricity (%) and potential harvest (ton) were considered with equal weightages of 25%. The beneficial criteria for analysis are Market Size (kg of Yarn) , Access to electricity (%) and potential harvest (ton) which needs to be maximum and non-beneficial criteria is Cost parameter which needs to minimum. Weightage normalized performance Value was calculated for all districts and the most favorable district was found. Thus, linear normalization was done for both beneficial and non-beneficial criteria as below:

For Beneficial criteria Market Size (kg of Yarn), Access to electricity (%) and potential harvest (ton)

$$\text{Normalized value} = \frac{Value\ of\ critera\ in\ that\ district}{Maximum\ value\ of\ that\ critera\ in\ all\ districts}$$

For Non-beneficial criteria Cost parameter

$$\text{Normalized value} = \frac{Minimum\ Value\ of\ critera\ in\ all\ district}{Value\ of\ \ critera\ in\ thatdistricts}$$

Thus, amongst all the district, the Weightage normalized performance Value for Pyuthan was found to be the highest thus Pyuthan was chosen. Checking the potential harvest of raw bark from these four districts, the cost parameter and yarn production capacity of district, Pyuthan district is found to be best suited for nettle processing unit. Based on the volume of yarn sold, Pyuthan ranks the highest thereby confirming the market size. The access to electricity is also best when compared to the lowest four costing districts. The number of entrepreneurs involved and the number of micro-enterprise group is also high for its neighboring district.

Table 5 Multi Criteria Decision Analysis for selection of District

Objectives		**Non beneficial (min)**	**Beneficial (max)**	**Beneficial (max)**	**Beneficial (max)**	**Weightage normalized performance Value**
Weightage		25%	25%	25%	25%	
Maximum values for beneficial criteria and minimum value for non-beneficial criteria of all districts		731.2292	7,200	100	73	
Province	Districts	Cost Parameter	Market size (kg of yarn)	Access to electricity %	Potential Harvest (Ton)	
3	Ramechhap	0.5596196	0.416667	0.997086	0	0.493343
	Sindhupalchok	0.5778664	0.635417	0.957195	0.136986	0.576866
	Kabhre	0.5915744	0.013889	0.899819	0.479452	0.496184
	Dolakha	0.564096	0.004167	1	0.273973	0.460559
4	Baglung	0.9628675	0.027778	0.904341	0.753425	0.662103
	Parbat	0.9611522	0.666667	0.914389	0.547945	0.772538
	Myagdi	0.9603275	0.25	0.927954	1	0.78457
5	Pyuthan	1	1	0.944534	0.958904	0.975859
6	Jumla	0.7641234	0.001389	0.193931	0.753425	0.428217
	Kalikot	0.770633	0.008333	0.437801	0.493151	0.42748
	Dailekh	0.8189412	0.006944	0.48965	0.890411	0.551487
	Surkhet	0.8254247	0.005556	0.48332	0.273973	0.397068
7	Darchula	0.5760522	0.083333	0.407757	0.30137	0.342128
	Baitadi	0.5815527	0.059028	0.345257	0	0.246459
	Dadeldhura	0.5997182	0.138889	0.802251	0.178082	0.429735

4.3.2 Size/Volume of Production:

For the cluster considered above, an estimate of 70 ton of Potential Stock can be extracted from Pyuthan itself. Thus, the input for this factory layout is a minimum of 70 ton per year. This may still be an underestimate as only one district is considered. Yet the minimum volume of production can be estimated. If the input raw material the whole cluster is considered the access to potential raw material is 238 ton/ annum

4.4 Carding Processes:

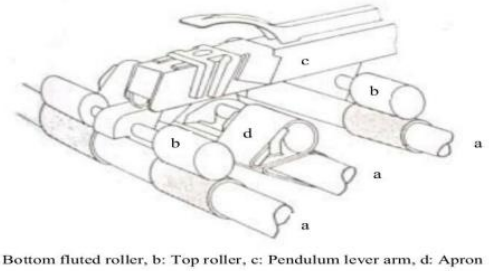
The Carder selected for this process had the specifications as below. The machine is tested in various input flow rates and the output slivers will be measured at variable speeds to find the optimal flow rates for sliver formation. Methods for calculation of sliver is:

Desired output of yarn is Metric count: 2, meaning 1kg fiber needs to be elongated and twisted into 2000 m length. Considering a coarse draft ratio of 2.5:1, the sliver before drafting needs to be 2000m / 2.5m i.e., 800 m, following this inverse kinematics, the carding machine needed to give the output of 0.8m/kg. For this production rate, the carding machine was fed at drum speed of 300 rpm to get this output. The output was condensed into a sliver ready to be spun.

For a continuous input of 5kg/hour hackled fiber, the total carded fiber produced was 4.6 kg/hour. The yield for this process was found to be 92%.

4.5 Combined drawing and spinning

For simplified production of yarn in the planned small-scale industry, the intermittent drawing process is considered such that the carded fibers can directly be sent to spinning machine. The spinning machine with 3-line single-apron drafting system is chosen.



a: Bottom fluted roller, b: Top roller, c: Pendulum lever arm, d: Apron

Figure 14 Single apron draft before spinning

Table 6 Specification of carding being tested

Feeding width	400mm
Working width	360mm
Cylinder diameter	Φ450mm
Doffer diameter	Φ220mm
Licker-in diameter	Φ165mm
Working roll diameter	Φ110mm
Wipe roll diameter	Φ90mm
Speed	Adjustable (Frequency converter control)
Max. fiber length	about 100mm
Main machine power	AC220V/380V, 50/60Hz, 750 W

For this process, the testing of a New Model Eight Spindle Charkha is done. This spinning equipment is mass manufactured since Khadi revolution in India and have been used in Polyester, cotton, wool and even silk. The machine can be used to produce a versatile range of thread count by changing the gear ratio for choosing draft and twist. This machine was used to at its standard configuration and pure nettle yarn of 2 counts was manufactured. 3kg Input sliver was spun and found to produce no loss in output thereby producing 100% yield. But the aggregated yield of processing becomes 50 % ($= 90.13\% \; x \; 67\% \; x \; 90\% \; x \; 92\% \; x \; 100$)

Figure 15 New Model Charkha under Use

4.6 Proposed Plant Layout

The plant designed have a sequence of machinery processes in sequence such that output of the preceding step is the input for proceeding step, thus a product layout has been chosen amongst all other plant layout types. The processes are sequenced such that the raw bark is first cooked, beaten, hackled, carded and spun. All the processes are shown in figure 18. The processes in the plant layout are defined.

For an annual input stock of 70 ton for Pyuthan district as defined in the size/capacity of the plant, the daily output production capacity required becomes 250 kg/day i.e., 31.25kg/hr. (assuming 280 working days/year and 8 hour/day working shift for the plant). Now, to define the quantity of each machines the production capacity of each machine is presented below in the table along with the process yields of each process. The processing output of each machine have been drafted in the table below along with the

To calculate the number of machines required in the plant layout, the desired processing capacity 31.25kg/hr. have been multiplied by yields of all the processes prior to it to find the total processing capacity needed in the stage. For example, capacity of beating machines must be such that the machines should be able to process all cooked bark from the cooking process that is, 31.25kg/hr. x 90.13% = 28.16kg/hr. But a single machine will produce only 11.38kg/hr. thus the number of machines was calculated by $\frac{16.89kg/hr}{11.38kg\ per\ hr}$ = 2.47, i.e., one machine will not be sufficient in the production process. Thus 3 beating machines are added

into the plant layout. Similar calculations have been done for all the processes to calculate the number of machines required in each step in Table 8. Thus, 3 cookers, 3 beating machine, 2 hackle, 4 carding machines and 63 Charkhas of pre-defined specification are required in the setup.

4.7 Daily Manpower, Electricity, Water and Utilities Consumption

The plant layout consists of 5 different processes and 75 machines. These machines are arranged in product layout fashion. For each machine, daily human resources requirement has been logged based on previous testing experience. The peak power is calculated by adding rated power of all the machines. Daily Energy consumed is calculated based on the machine load previously calculated in table 7, power rating and 8 hours usage per day. Water is heavily used first to cook the fiber in the ratio 1:5 (Fiber : Solution). Later, rinsing takes up even more water at 1:8 (Fiber: Clean water). These rations have been previously established under yields of pre-processing. Daily cooking consumes 44.88kg NaOH as 4% NaOH solution needs to be prepared at a volume of 1122 ltrs cook. Another 1950 ltrs of water is estimated to wash NaOH from the fiber in beating stage.

Based on calculations from Table 8, a daily production of 125.5 kg yarns requires Daily output, 31 men are employed, Total energy consumed per day is 421.52 Kwhr (units) at 58.05Kw peak load power. A daily requirement of 3072 ltrs water is needed for the processes.

The plant needs the following operations for conversion of raw bark to yarn:

Input:

Raw bark

Output:

Machine Spun Yarn

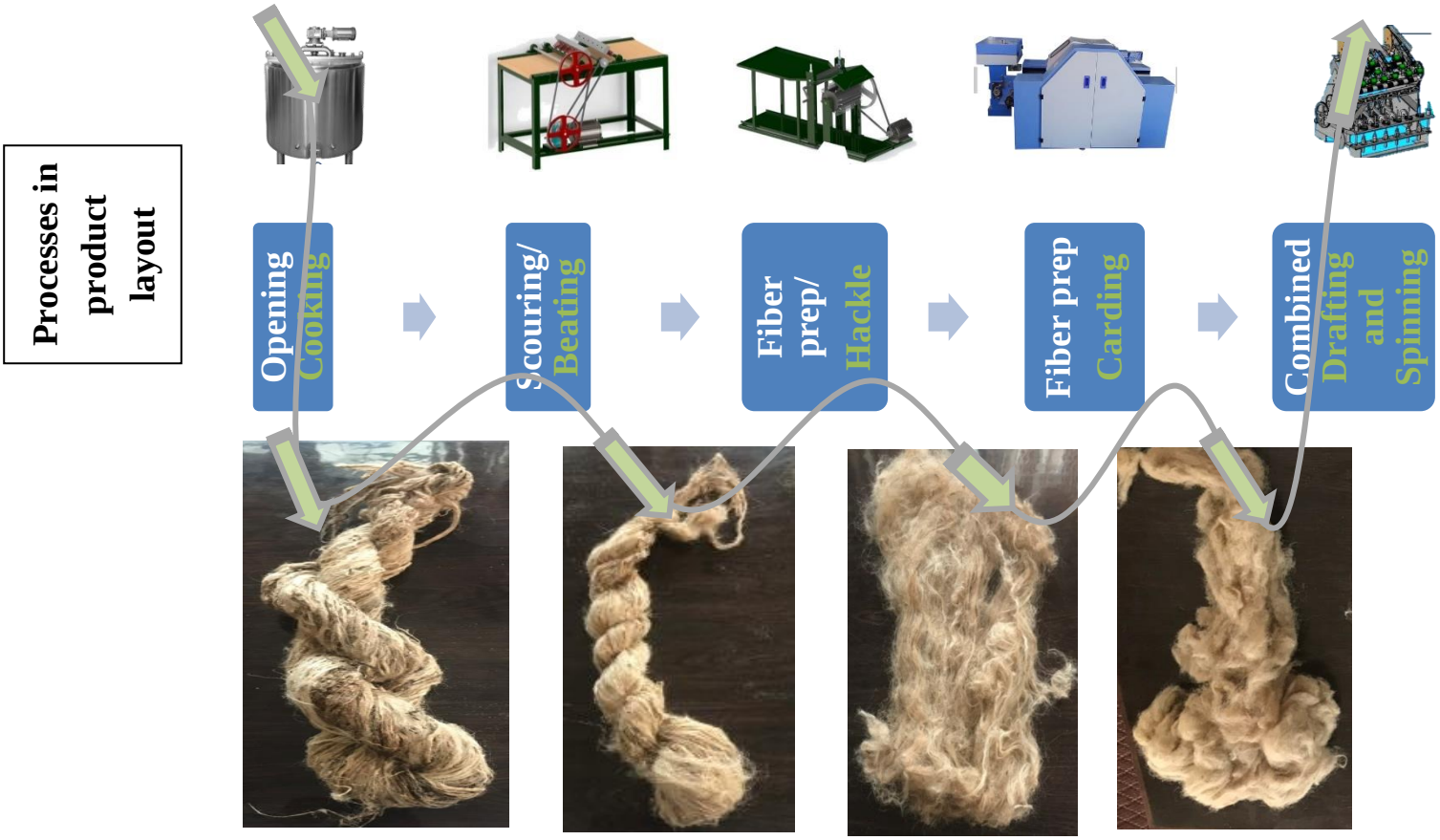


Figure 16 Processes in the plant layout

Table 7 Calculation for number of machines required in plant layout

SN	Machine Name	Specifications	Input fed (kg/hr.)	Process Yield	Output produced	Load on machines and Number of machines required
1	Cooking Vessel	3 Phase 9 KW PID Controlled 200 ltrs double jacketed SS Cooking vessel	At fiber consistency of 1:5 (Fiber:NaOH Solution), 40kg raw bark can be cooked in 3 hrs., Thus, 13.33 kg/hr input	90.13%	12kg/hr	$=\frac{31.25\ kg\ per\ hr}{12kg\ per\ hr}$ = 2.6 load on the machine rounded off to whole number **3 cookers**
2	Beating Machine	1.5KW. 3 phases, Direction controlled, Hammer at 150stroke/min at linear speed of 40mm/sec	Tested at 17kg/hr	66.98%	11.38kg/hr	$=\frac{31.25\ kg\ per\ hr\ X\ 90.13\%}{11.38kg\ per\ hr}$ = 2.48 load on the machine i.e., 2 machine cannot meet the production capacity so, **3 set machines required**
3	Hackle	0.75KW 3 phase, manually controlled roller fed at 10mm/sec and combed at 270 rpm	Tested at 12kg/hr	90.50%	10.86kg/hr	$=\frac{31.25\ kg\ per\ hr\ X\ 90.13\%x67\%}{10.86kg\ per\ hr}$ = 1.74 load on the machine i.e., 1 machine can meet the production capacity so, **2 set machines required**

4	Carding Machine	0.75KW 3 phase, VFD Controlled for 300 rpm for given specification of machine	Tested at 5kg/hr	92%	4.6kg/hr	$=\frac{31.25\ per\ hr\ X\ 90.13\%x67\%x90\%}{4.6\ kg\ per\ hr}$ = 3.69 load on the machine i.e., 1 machine cannot meet the production capacity so, **4 set machines required**
5	Combined Drafting and Spinning NMC-10	0.35KW, set at 130 rpm input for given specification of machine	Tested by loading 10 creels of 150 gm each, spun in 10 spindles in 6 hrs.	100%	0.25kg/hr	$=\frac{31.25\ kg\ per\ hr\ X\ 90.13\%x67\%x90\%\ x\ 92\%}{0.25\ kg\ per\ hr}$ = 62.5 rounding off, **63 set machines required**

1. The processing areas:

The area required for each of the amenities are calculated. The processing area under main factory space is divided into Cooking Area, Beating and rinsing area, 2 Fiber Preparation areas for hackling and carding and a spinning area. Of all these areas, carding area has been enclosed in a room as carding process is temperature and humidity sensitive.

Cooking area consists of 3 cooking vessels as defined in table 9 and a chemical rack along with a lot of working space around the machine. It is directly connected to the inventory area such that raw material can be moved to the cooking area using hand pallet loader. The beating and rinsing area consist of 3 beating machines, a washing bay and a hydro water extractor. The fiber preparation area 2 consist of hackle and material rack. The machines in these 3 areas are placed such that there is a workable space of 1m on all sides around machines. Total area for these 3 pre-processing stages is 10m x 7.5m as shown in the figure 19.

The carding area under fiber preparation area 2 has been separated from the main factory area as air conditioning is needed for carding space. Four carding machines of predefined

sizes along with workable space of 1m around the machines is kept around the machine with ample sliver storage space. The area is 4.5m x15m.

The main factory space is then vested for 63 spinning machines, 24 yarn storage racks and a tool store. These machines are distributed in an area of 20m x 14.5 m as shown in the figure 19.

Table 8 Daily Raw material, Labor, Electricity and utility in each processing steps

Name	Cooking Vessel	Beating Machine	Hackle Machine	Carding Machine	NMC 10 spindle Charkha	Total
QTY	**3 sets**	**3 sets**	**2 set**	**4 sets**	**63 sets**	**75 Machines**
Input at each stage	**250 kg**	**225 kg** (= 250kg x 90% preceding yield)	**150.75 kg** (= 250kg x 90% x 67% preceding yields)	**136.42 kg** (= 250kg x 90% x 67% x 90.5%)	**125.50 kg** (= 250kg x 90% x 67% x 90.5% x 92%)	Daily output: **125.5kg yarns**
Manpower	**3 men**	**6 men**	**4 men**	**8 men**	**10 men**	**31 men**
Electric energy and peak power load	**187.2Kwhr** (9Kw x 2.6 machine loading for 8 hours) **27Kw** for 2 machines	**26.74Kwhr** (1.5Kw x 2.48 machine loading for 8 hours) **4.5Kw** for 2 machines	**10.44Kwhr** (0.75Kw x 1.74 machine loading for 8 hours) **1.5Kw** for 1 machine	**22.14Kwhr** (0.75Kw x 3.69 machine loading for 8 hours) **3Kw** for 2 machines	**175Kwhr** (0.35Kw x 62.5 machine loading for 8 hours) **22.05Kw** for 38 machines	**421.52 Kwhr (units)** at **58.05Kw peak load**
Water and utilities	**Water: 1122 ltr** (187 ltrs x 6 batches per day) **NaOH:44.88 kg crystal form**	**Water: 1950 ltr** (325 ltrs x 6 batches per day for washing off NaOH)	**Maize flour: 12.56kg (**1:12 Flour: Fiber)			3072 ltrs water 45kg NaOH 12.56kg Maize floor

	(4% x 187 ltrs x 6 batches)					
Floor area needed. For each machine	**3m2** for 3 cookers of max diameter 900mm each	**4.2m2** for 3 machines of max 2 m x 0.7 m floor area	**4.05m2** for 2 machines of max 1.8m*1.5m floor area	**23m2** for 4 machines of max 3.2m x 1.8m max floor area	**50.4m2** for 63machines of max 1m x 0.8m max floor area	Minimum 84.65 m2 for all the machines without any human working space.

2. Supervisors' office and staff quarter

The management and unskilled labor shall be not be facilitated with the staff accommodation facility for the smooth operation, the factory is planned to operate with in house skilled manpower and supervisors. As planned for machine operation, a common living space will be built to facilitate up to 18 staffs. A toilet will be placed nearby. A 15 m x 5m container like space is planned for it.

The office space will accommodate 3 supervisors, an accountant, a small meeting space and a manager's table. A 3m x 9m space is planned for it. A toilet will be placed adjacent to the office. The staff accommodation area along with office space is designed in plot 2 (See in the picture).

3. Toiletry and water wells

The factory's water usage in industrial processes occurs in cooking area and rinsing area where in 3072 ltrs water will be used daily as per table 9. Other water usage is in the sanitary and toiletry application.

Mainly for a factory of this span, 2 staff toilets are planned. 2 staff toilets shall be located in the near staff quarter. Over estimating a water well of 50 ft well, a submersible motor shall be placed along with 3x 5000 ltrs tanks for factory/sanitary usage.

4. Transformer:

The total peak power requirement for this plant has been estimated to be 58.02 KW at scheduled operation when all machines are run at defined time. As per the predefined machine layout, the electrical distribution had been planned. For this mix load of 45 machinery, 27Kw of the total 58.02 Kw is consumed in heating operation therefore the power factor can be considered 1, similarly for the remaining 31.02Kw, load are induction motors can produce a power factor as low as 0.5 (K.E. Ad'doweesh, 1990). Thus, the total load of machines is estimated to be $\frac{27}{1} + \frac{31.02}{0.5}$ KVA i.e., 89.04 KVA. Air conditioning load for Fiber processing area 2 is estimated using Energy Consumption Guide 19 (The Government's Energy Efficiency Best Practice programme, 2000) . The Type 4: Air-conditioned prestige model is the most premium model and it estimates power density 18 W/m2 floor area. For our floor area 15m x 4.5m (of Fiber processing area 2), the total power is estimated to be 1.215 KW i.e., 2.43KVA. Overall lighting and other utilities are estimated to produce 10% overhead for the factory. Thus, the peak power adds up to be 91.47KVA. Thus, a standard 100KVA transformer can bear all the load requirement.

The structural shed of span 15m x 27m for process machinery, 15m x 5m truss for staff quarter, 3m x 9m plain truss of supervisor's office, 16.4m x 6.4m plain truss for inventory are planned.

4.9 Quality Assurance of produced yarn:

For QMS of a small-scale spinning factory, the following equipment should be used to test the quality of yarns produced.

a. Yarn Strength and elongation Tester: Bast fiber can vary in strength, and fine yarns are more susceptible to breaking under tension. Testing yarn strength is essential to ensure the yarn can withstand processing and end-use conditions. A yarn strength tester, also known as a tensile strength tester or yarn tensile tester, is a device used to measure the breaking strength of yarn. It evaluates how much force a yarn can withstand before it breaks. This information is crucial for assessing the yarn's durability, suitability for specific applications, and overall quality. Here's how a typical yarn strength tester works: A representative sample of the yarn to be tested is prepared. The sample is carefully

selected and mounted on the testing machine. The length of the sample is typically specified based on industry standards. The ends of the yarn sample are securely clamped onto the testing machine. This ensures that the yarn remains taut and that the force applied during testing is evenly distributed across the sample. The testing machine sets the yarn sample to an initial resting position, usually at a specific tension level. This tension is often referred to as the "preload" or "zero load" tension. The testing machine is equipped with load cells or force transducers that measure the force being applied to the yarn along with the displacement readings to calculate elongation. This force is typically measured in units of Newtons or pounds-force. As the force is increased, the yarn will stretch until it reaches a point of failure or breaking. The testing machine's sensors detect this breaking point based on the force reading. The force at which the yarn breaks is recorded. The testing machine calculates and displays the breaking strength of the yarn. This value is usually reported in units such as Newtons or pounds-force. Additionally, elongation at break indicates how much the yarn stretched before breaking. Overall, a yarn strength tester helps manufacturers ensure that the produced yarn meets the required strength specifications and can withstand the stresses it will encounter during weaving, knitting, or other downstream processes and end uses. Model YG020A Electronic Single Yarn Strength Tester is selected for this purpose.

b. Yarn Twist Tester: A yarn twist tester is a device used to measure the twist in a yarn. Twist refers to the spiral arrangement of fibres around the central axis of the yarn. Twist is critical for the strength, appearance, and processing of bast fiber-based fine yarns. Proper twist ensures that the yarn holds together and behaves as expected during downstream processes. The yarn twister works in the following way: the length of the sample should be sufficient to obtain accurate twist measurements. The sample should be straightened and free from any kinks or tangles. One end of the yarn sample is securely attached to a fixed point on the twist tester. The other end is attached to a rotating spindle. The spindle can rotate freely, allowing the yarn to twist around its axis. The spindle holding the yarn is rotated, introducing twist into the yarn. The rotation can be controlled at a specific speed and direction (clockwise or counterclockwise). The amount of twist introduced is usually specified in terms of turns per inch (TPI) or turns per meter (TPM). The twist tester might also indicate the direction of twist introduced into the yarn, whether

it's S-twist (clockwise) or Z-twist (counterclockwise). This information is important for downstream processes that involve combining multiple yarns with different twist directions. Twist testing can be performed on multiple samples to ensure consistency and accuracy of the results. Model GT-A08 semiautomatic yarn twist counter is appropriate for our applications.

c. Yarn Count Tester: Fine yarns require precise measurement of their linear density. Accurate yarn count measurement helps maintain consistency in the yarn's thickness. This is done by carefully measuring the weight of a definite length of sliver/rove/yarn. The found weight is divided by the length of fiber based on the industrial standards (like Nm, Ne, Tex, Denier) used. Weighing scale of readability of 50mg and capacity 1 kg maximum can be used for measuring weight and meter scale can be used to measure the length of yarn.

For the quality assurance, a textile engineer and the above sets of testing equipment will be added for frequent testing of output and quality control recommendations.

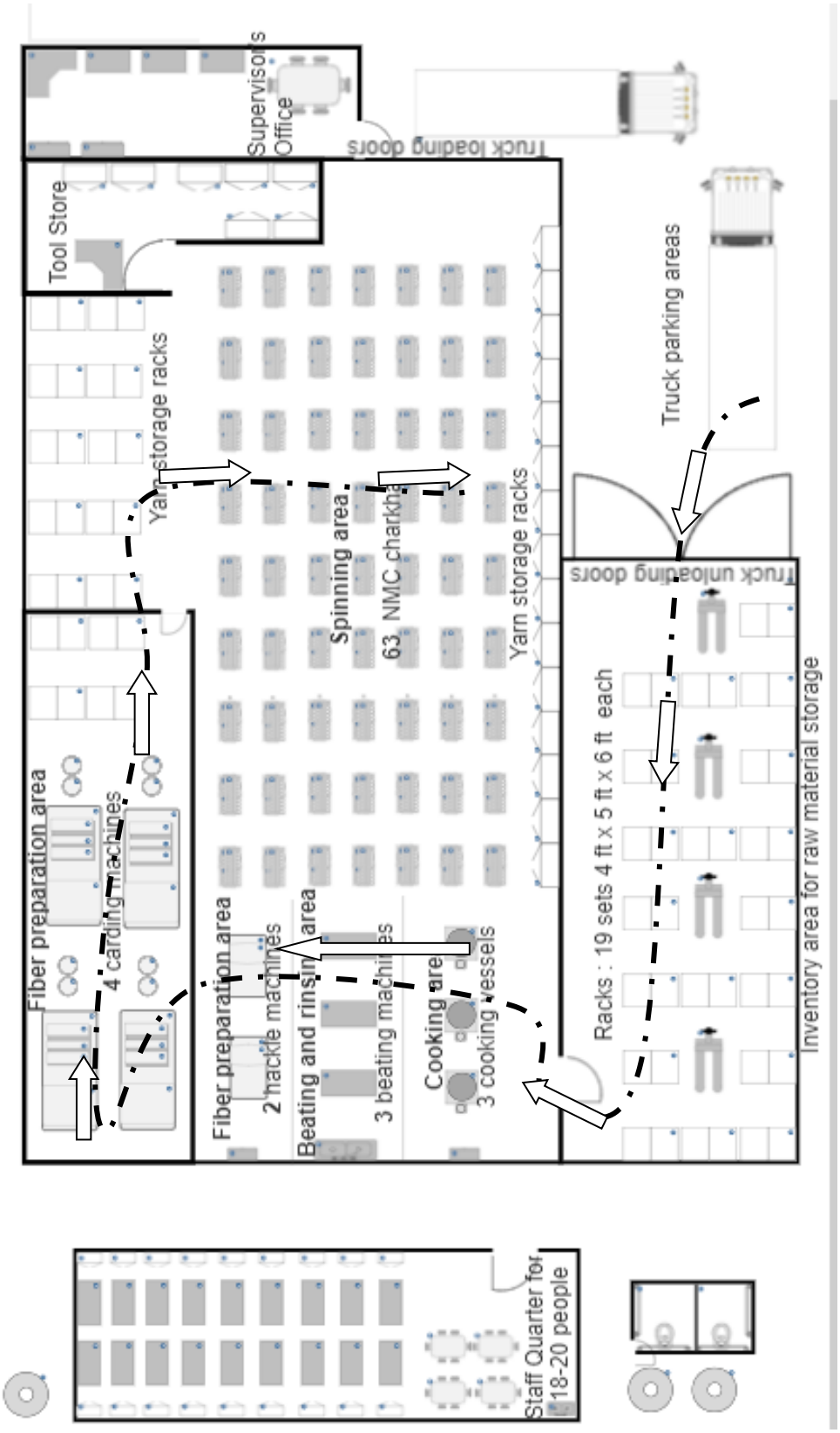


Figure 17 Material flow and Floor plan of factory setup

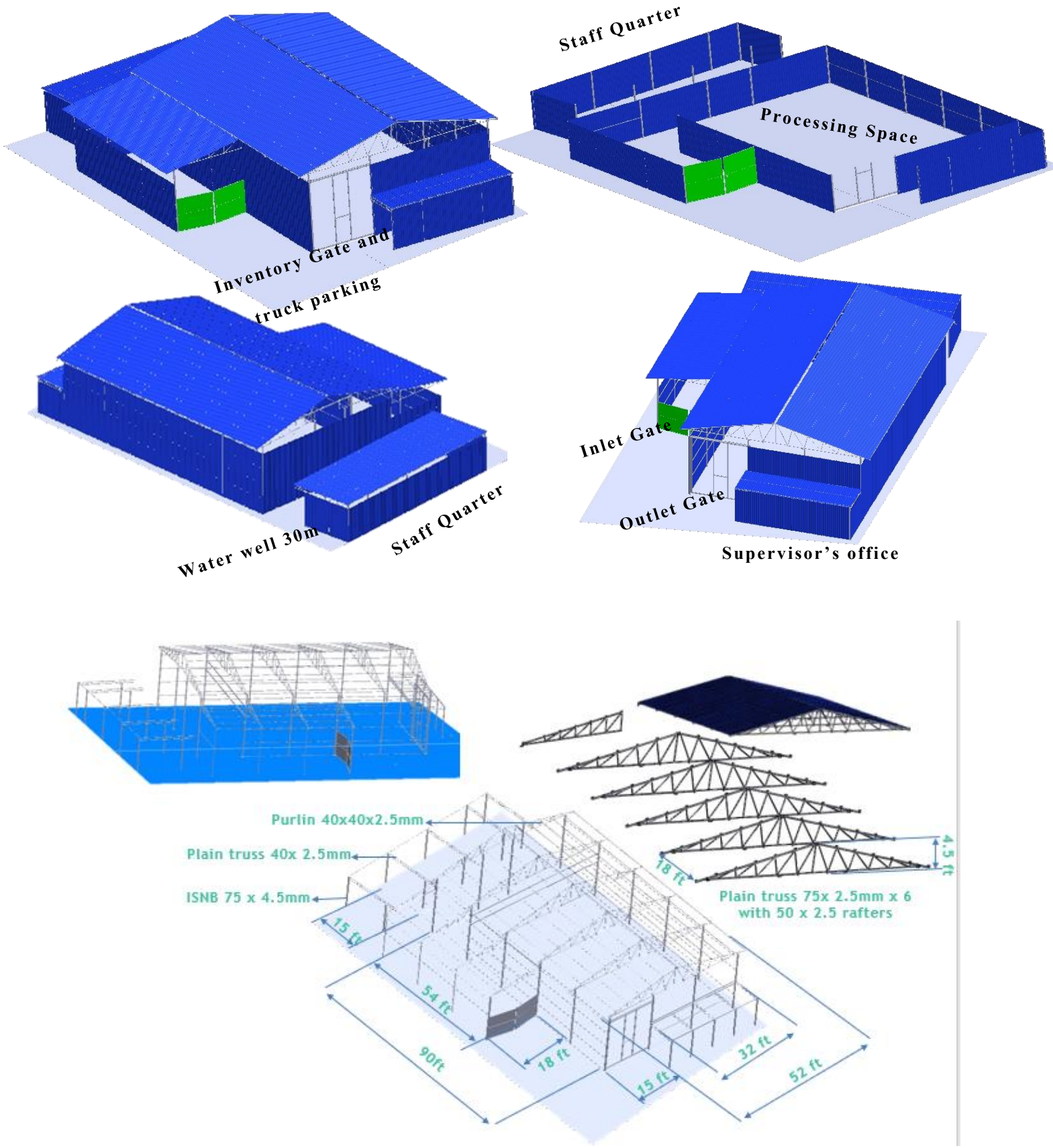


Figure 18 Structural Shed for the factory

4.10 Cost of Establishment of the Plant

Planning of a factory incorporates 3 major expenses. The cost of establishment of the plant is divided into Factory Civil works cost, Machinery Assets procurement and Operational Expense. These 3 costs are tabulated under 3 different tables below:

Table 9 Cost of Civil Works

Headings Civil Works Cost (A):	QTY	Rates Nrs/ Unit	Asset cost
Structural shed excavation with PCC, RCC, Steel structure, H span wall and roof along with Cement board structures for auxiliary sheds QTY in sqm units (Rate analysis done)	7309.0	1031.58	**7,539,800.11**
Boundary wall wire mesh for land area 22.5m x 31.2m x 2m high (QTY sq m units)	214.8	350	75180
Electricity transformer and wiring (Quotation based rate for 100 KVA transformer with TOD Meter and distribution box)	Turn key	1885000	1885000
Water Well and Motor QTY 100 ft deep (Inquiry based rate)	100	2100	210000
Toilet (1 office + 2 staff) (Inquiry based rate)	2	105000	210000
Total Civil works cost (A)			**9,919,980.11**

Major share of Civil works cost is spent in the construction of factory building. The design details of the factory shed is given in Figure 20. The detail rate analysis of this cost is attached in the annex. The rate analysis of Civil Works is based on Jilla Dar rate (District rate analysis

for construction material and work). Remaining costs are based on the quotation received from the relevant service providers.

As specified in the section 4.7 previously, the rates and quantity of all machines are incorporated to find the Machinery Asset Procurement (B) under the table below. The rates of machines have been consulted from Nepalese, Chinese and Indian manufacturers and an additional transportation, customs duty, banking costs, installation charges etc. have been added to it by Nepalese machinery importers.

Table 10 Cost of Machinery Asset

Headings Cost of Machinery Asset Procurement:	QTY	Rates Nrs/ Unit	Asset cost
Cooking Vessel	3	255,000	765000
Beating Machine	3	215,000	645000
Hackle Machine	2	95,000	190000
Carding Machine	4	1091062.5	4364250
NMC 10 Spindle Charkha	63	96278	6065514
Cost for yarn testing tools and spare parts taken 5% of machine cost	601488.20	601488.20	601488.20
Total Cost of Machinery Asset (B)			12,631,252.20

The cost of initial management (C1) includes one-time investment done in consultant fees, supervision and liaison fees, office setup, Furnishing, Registration and (Udhyog Darta,company registration, VAT, Banijya, EXIM and Quality Certificate etc.). These expenses do not repeat yearly, but expenses on Legal & Accounting consulting, Salary (12 months and 1-month Dashain Bonus for 2 supervisor, 1 textile engineer, 1 manager and 31 semi-skilled manpower), Land Lease, Marketing and travel expense, Raw Material (70-ton Bark), Cost of Electrical energy and demand charges occur on a recurring basis and are accounted under Cost of yearly operation (C). Thus, for projected cash flow diagrams C will be taken as the yearly recurring figure.

The capital structure can be managed up to 30% by bank financing as the banks can finance up to 30% for manufacturing plants. In such case, a cost of loan financing is induced in paying back the interest and the principal. Minimum cost of financing for this market condition levied by commercial bank as per Nepal Rastra Bank base rate guidelines is a minimum of 13% .

Table 11 Cost of Initial management and yearly operations

Headings Cost of yearly operation (C)	QTY	Rates Nrs/ Unit	Asset cost	Type of cost
Pre-Opening consultant fees for supervision of construction for 6 month (1 man for 6 months)	**6**	**50000**	300000	One-time
Procurement Liasson for all machinery from India and China (2 mechanical Er. For 3 months) i.e., 6-man months	6	40000	240000	One-time
Misc. Start-up Costs (factory office setup + Furnishing + Warehousing racks)	1	500000	500000	One-time
Registration and Certifications (Udhyog Darta and other Certificates)	LS	150000	150000	One-time
Legal & Accounting consultant 2x 13 months	26	25000	650000	Yearly Recurring
Salary (2 Skilled Supervisor+1 textile engineer + 1 MANAGER) for 13 months i.e., 52-man month	52	35000	1820000	Yearly Recurring
Salary (31 semi-skilled) for 13 months i.e., 403-man month	403	27000	10881000	Yearly Recurring
Land Lease 3.5 ropanis for 1 years (reference value taken based on enquiry for rural Lalitpur)	3.5	20000	70000	Yearly Recurring
Market travel (1 marketing personnel x 10 purchaser x 3 days each) 140-man day travel	30	4000	120000	Yearly Recurring
Raw Material 70-ton Bark for 1 year (reference rate taken based on purchase of raw material for experimentation done for yield)	70000	200	14000000	Yearly Recurring
Cost of Electricity 91.47 KVA Demand charge for 12 months as per (विद्युत महसुल संकलन विनियमावली, २०७८)	1097.64	110	120740.40	Yearly Recurring

Cost of Electricity 58.02 Kw Peak demand for 8 hours, 280 days, 2 years at 9.5 Rs/unit as per (विद्युत महसुल संकलन विनियमावली, २०७८)	129964.8	9.5	1234665.60	Yearly Recurring
Cost of Chemical NaOH (44.88 kg per day for 280 days)	12566.4	300	3769920	Yearly Recurring
Cost of Water supply (3072ltrs/day for 26 days x 12 months) at the KUKL Tariff rates for 1in Piped water connection (((3.072kl*26day - 56klm minimum quantity for tariff)x71 tariff for quantity above 56kl+3960 minimum charge+9560 monthly fixed charge)x1.5 for sewerage service 50% extra (KUKL, 2079)	12	22822.38	273868.42	Yearly Recurring
Cost of maintenance of machinery 5% of cost of asset	5%	12631252.2	631,562.61	
Total Cost of Initial management and operation yearly operation (C+C1)			**34761757.03**	**33571757.03 (C)Recurring expense every year**

Table 12 Total Capital requirement with timeline and yearly expense

Headings of Cost	Nrs	Financial timing
Total Civil works cost (A)	9,919,980.11	Within 6 months of project commencement
Total Cost of Machinery Asset (B)	12,631,252.20	Within 6-12 months of project commencement
Cost in Initial management (C1)	1,190,000.00	Within 6-12 months of project commencement
Cost of yearly operation (C)	33,571,757.03	Within 12-24 months of project commencement
Total Cost (A+B+C+C1)	57,312,989.33	**Within 24 months of Project commencement**
Loan Capital 30%	17,193,896.80	Within 6-12 months of project commencement
Paid up Equity Capital 70%	40,119,092.53	
Cost of loan financing (C2) @13%pa	2,235,206.58	**Yearly Interest paid**
Cost in First year (A+B+C1+C2)	59,548,195.92	**Paid first year**
Cost in Second year (C+C2)	35,806,963.61	**Paid every year**

Depreciation of assets, growth of land lease and increment of salary all add to the yearly expense thereby increasing the expenses yearly. The depreciation of assets has been calculated by assuming the salvage value of machinery to 10% of total Cost of Machinery Asset (B) after 15 years of use. An accelerating model of depreciation is used for calculating yearly depreciation to be deduced from expense. Accelerated depreciation uses decreasing charge methods, including the sum-of-the-years' digits (SOYD), providing higher depreciation costs in earlier years and lower depreciation charges in later periods.

Under the SOYD method, the depreciation rate percentage for each year is calculated as the number of years in remaining asset life for the same year divided by the sum of remaining

asset life every year through the asset's life. As the depreciation rate decreases over time, so does the depreciation charge. It makes sense to use an accelerated depreciation method such as the SOYD method when an asset will lose most of its value toward the beginning of its useful life. For our project life of 15 years, machine will operate for 14 years as defined in the table above, salvage value of Nrs 11,368,127,

Table 13 Depreciation of assets over project life

Years of machine operation	**14**	**years**	
Salvage values of Machine set to 10% of Machinery cost (10% of B)	**1263125.22**	**Nrs**	
Total Depreciation book value	**11368126.98**	Sum of years:	∑1-14=105
SOYD Book Value depreciation year 1	1515750.26	Ratio for year 1:	14 /105
SOYD Book Value depreciation year 2	1407482.39	Ratio for year 2:	13 /105
SOYD Book Value depreciation year 3	1299214.51	Ratio for year 3:	12 /105
SOYD Book Value depreciation year 4	1190946.64	Ratio for year 4:	11 /105
SOYD Book Value depreciation year 5	1082678.76	Ratio for year 5:	10 /105
SOYD Book Value depreciation year 6	974410.88	Ratio for year 6:	9 /105
SOYD Book Value depreciation year 7	866143.01	Ratio for year 7:	8 /105
SOYD Book Value depreciation year 8	757875.13	Ratio for year 8:	7 /105
SOYD Book Value depreciation year 9	649607.26	Ratio for year 9:	6 /105
SOYD Book Value depreciation year 10	541339.38	Ratio for year 10:	5 /105
SOYD Book Value depreciation year 11	433071.50	Ratio for year 11:	4 /105
SOYD Book Value depreciation year 12	324803.63	Ratio for year 12:	3 /105
SOYD Book Value depreciation year 13	216535.75	Ratio for year 13:	2 /105
SOYD Book Value depreciation year 14	108267.88	Ratio for year 14:	1 /105

Similarly, land lease and yearly salary add to yearly expense in a compounding fashion. The land lease is assumed to increase at the rate of 5% per year. For the approximation of salary growth rate in the Nepalese market, Salary and Wage rate Index (SWRI) has been taken into account. SWRI based on Annual Data of 2021/22 indicates a growth 6.65% of year-on-year growth is seen (NRB Economic Research Department, 2022). Using this macroeconomic

index for increasing rate of salary every year, the salary increment is calculated for each year using compounding formula.

Salary calculated for 35 human resource for 13 months as per table 12 adds up to Nrs 12701000.00 for year 1. The land lease at year 1 in Nrs 70,000. Yearly increment of salary and land lease have been compounded as follows:

$$Increment\ in\ Salary\ \Delta S$$

$$= Year\ 1\ Salary\ x\ [(1 + 0.065)^{Running\ Year} - 1]$$

and

$$Increment\ in\ land\ lease\ \Delta L$$

$$= Year\ 1\ land\ lease\ x\ [(1 + 0.05)^{Running\ Year} - 1]$$

In the future, many hydropower projects are being connected to Nepal's grid. The total grid connected power of 2190MW for 2021/22 is planned to scale up to 6883 MW in 2027/28 even if only projects whose power purchase agreement have been completed are taken into account. The total grid connected power is planned to scale up to 7453 MW in 2027/28 even if all projects whose power purchase agreement (PPA) have been completed or PPA in progress or PPA in pipeline are taken into account. These data are tabulated under annexes and are sourced from NEA's Annual reports 2021/22. These data establish the trend of generation over the year to be hugely increasing. (Nepal Electricity Authority, 2022)

But, according to the load forecasted by NEA under System Planning Department (Nepal Electricity Authority, 2015), the base load of 2378.9 MW on 2021/22 will only increase to 3439.5 MW on 2027/28. This indicates a massive energy surplus on supply side as the installed capacity will reach at least 6883MW with signed PPA. These figures are indicative of future of energy price either stagnating in the value or declining due to supply demand mismatch. Thus, the hike in electricity cost over the years is not considered in the report ahead.

The compounding increases expenses is seen. Along with this rate of increment, expense added is yearly depreciation as calculated in table 14. Thus, yearly increased expense is tabulated in the table below:

Table 14 Yearly increasing salary, land lease and total expense

Years	Increment in land Lease ΔL	Increment in salary ΔS	Yearly depreciation (D)	Yearly Increased Expense ($\Delta S + \Delta L + D$)
Year 2	3500.00	1154520.90	1515750.26	38480734.77
Year 3	7175.00	2413987.75	1407482.39	39635608.75
Year 4	11033.75	3787940.14	1299214.51	40905152.01
Year 5	15085.44	5286784.79	1190946.64	42299780.48
Year 6	19339.71	6921874.43	1082678.76	43830856.51
Year 7	23806.69	8705593.72	974410.88	45510774.91
Year 8	28497.03	10651453.09	866143.01	47353056.73
Year 9	33421.88	12774191.07	757875.13	49372451.70
Year 10	38592.98	15089885.94	649607.26	51585049.78
Year 11	44022.62	17616077.47	541339.38	54008403.09
Year 12	49723.76	20371899.82	433071.50	56661658.69
Year 13	55709.94	23378226.41	324803.63	59565703.59
Year 14	61995.44	26657828.09	216535.75	62743322.89
Year 15	68595.21	30235545.56	108267.88	66219372.26

4.11 Projected Revenues and Profitability:

The production of yarn will start after 12 months of project commencement and gradually increase in capacity. The peak production capacity will be established within 24 months of project commencement. The daily production capacity of yarn for the plant is established to be 125.5 kg (250 kg per day x 90.13% x 67% x 90% x 92% yields of each step).

The market price of yarn depends on the count of yarn and purity. The finer the yarn, high will its count be and higher will the price be. Similarly, the scarcity of 100% pure yarn has created the price of yarn to be very high. Upon enquiry of cost amongst yarn traders, cost of 1 kg of 40 Nm 100% nettle yarn is Nrs 1800/kg, similarly Nrs1600/kg for 20 Nm 100% nettle yarn. Considering B2B margin of 15%, the factory prices of these yarn can be estimated to be Nrs1391.3/kg for 20 Nm 100% nettle yarn and Nrs1565.22/kg for 40 Nm 100% nettle yarn. With the 63 NMC charkhas having abilities to produce yarns from 1 Nm to 50Nm, the

factory can plan to split its production capacity such that 10% produce is Nm 40 yarns and the rest 90% to be Nm 20 yarns.

Table 15 Projected revenue for first year

Daily production capacity (a)	125.50	kg
Portfolio	40 Nm Yarn	20 Nm Yarn
Split production capacity (b)	10%	90%
B2B cost (c)	1565.22	1391.30
Product Split in weight (a x b)	12.55	112.95
Daily revenue (a x b x c)	19643.48	157147.83
Total Daily Revenue ∑ (a x b x c)	Nrs 176791.30	
Yearly Revenue ∑(a x b x c) x 280 working days per year	NPR 49,501,565.22	
Yearly Expense from second year(C+C2)	NPR 35,806,963.61	
Net Yearly Income	NPR 13,694,601.61	

But, revenue of any factory in manufacturing sector can be expected to grow over the years. This increase in revenue is calculated by the national economic indicator called Gross value added GVA. Gross value added (GVA) is the measure of the value of goods and services produced in an area, industry or sector of an economy. For example, in a manufacturing plant ,it indicates the difference between the revenue generated by a sector in producing the finished goods and the cost of raw material incorporated in making these finished goods, thereby indicating the value created by the manufacturing process.

The data of Gross Value Added in Millions NPR at current price for all industrial sectors are presented in the Annex. The increasing change of GVA for manufacturing subsector has been calculated from the data of 21year avg of y-o-y GVA growth rate for industrial subsector at current price in millions. Of these data, only data for manufacturing sub sector is tabulated above in table 15. Upon calculation of percentage growth of this value for last 21 years, it was found that y-o-y growth of GVA was majorly positive except for 2001/02 and 2019/20.

These can be correlated with the events of instability due to Royal massacre and COVID 19 respectively. Apart from this, the 21 years average of 9.2 % of growth was seen in GVA value. This average growth rate is taken as the compounding rate for revenue over the years of operation. Since the year 1 Revenue as NPR 13,694,601.61, the revenue for following year can be found by,

$$Revenue\ R\ in\ running\ year = Year\ 1\ Revenue\ x\ [(1 + 0.092)^{Running\ Year}\ ]$$

Table 16 Year on Year Change in GVA for Manufacturing sub sector

Year	Manufacturing GVA in Millions of Current price	Year on Year percentage change in GVA value (%)
1999/01	38409	
2001/02	37736	-1.75219
2002/03	38826	2.888488
2003/04	41673	7.332715
2004/05	44885	7.707628
2005/06	47840	6.583491
2006/07	52172	9.055184
2007/08	57185	9.608602
2008/09	65447	14.44784
2009/10	70924	8.368604
2010/11	80531	13.54549
2011/12	91164	13.20361
2012/13	100312	10.03466
2013/14	112995	12.64355
2014/15	118980	5.296695
2015/16	120967	1.670029
2016/17	133862	10.65993
2017/18	146589	9.507553
2018/19	192230	31.13535
2019/20	174014	-9.47615
2020/21	199562	14.68158
2021/22	231772	16.14035
Average % growth over 21 years		**9.203953**

Now, the total yearly expenses including depreciation and yearly increased revenue are presented in the table below. The profit before income tax (PBIT) has been accounted by reducing total yearly increased expense $(C + C2 + \Delta S + \Delta L + D)$ from the revenue in running year (R). The tax rate for FY 2079-80 (2022-23) dictates that industries that create export income are taxed at a rebated rate of 20% income tax (PKF T R Upadhya & Co , 2022). So, the profit after income tax (PAIT) is calculated by deducing 20% of PBIT. Thus, yearly profit after tax have been taken into cash flow projection for 15 years in figure 21.

Table 17 Yearly Expense, Revenue and Profit before and after Tax

Year	Increment in land Lease (ΔL)	Increment in salary (ΔS)	Yearly depreciation (D)	Increased Expense +depreciation ($C + C2 + \Delta S + \Delta L + D$)	Yearly increased Revenue (R)	Profit before Income Tax PBIT=R - ($C + C2 + \Delta S + \Delta L + D$)	Profit after income Tax PAIT= 80% of PBIT
Year 2	3500.00	1154520.90	1515750.26	38480734.77	49,501,565	NPR 11,020,830.44	NPR 8,265,622.83
Year 3	7175.00	2413987.75	1407482.39	39635608.75	54,055,709	NPR 14,420,100.47	NPR 10,815,075.35
Year 4	11033.75	3787940.14	1299214.51	40905152.01	59,028,834	NPR 18,123,682.46	NPR 13,592,761.84
Year 5	15085.44	5286784.79	1190946.64	42299780.48	64,459,487	NPR 22,159,706.76	NPR 16,619,780.07
Year 6	19339.71	6921874.43	1082678.76	43830856.51	70,389,760	NPR 26,558,903.55	NPR 19,919,177.66
Year 7	23806.69	8705593.72	974410.88	45510774.91	76,865,618	NPR 31,354,843.08	NPR 23,516,132.31
Year 8	28497.03	10651453.09	866143.01	47353056.73	83,937,255	NPR 36,584,198.11	NPR 27,438,148.58
Year 9	33421.88	12774191.07	757875.13	49372451.70	91,659,482	NPR 42,287,030.59	NPR 31,715,272.94
Year 10	38592.98	15089885.94	649607.26	51585049.78	100,092,155	NPR 48,507,104.88	NPR 36,380,328.66
Year 11	44022.62	17616077.47	541339.38	54008403.09	109,300,633	NPR 55,292,229.80	NPR 41,469,172.35
Year 12	49723.76	20371899.82	433071.50	56661658.69	119,356,291	NPR 62,694,632.43	NPR 47,020,974.32
Year 13	55709.94	23378226.41	324803.63	59565703.59	130,337,070	NPR 70,771,366.30	NPR 53,078,524.73
Year 14	61995.44	26657828.09	216535.75	62743322.89	142,328,080	NPR 79,584,757.43	NPR 59,688,568.08
Year 15	68595.21	30235545.56	108267.88	66219372.26	155,422,264	NPR 89,202,891.45	NPR 66,902,168.59

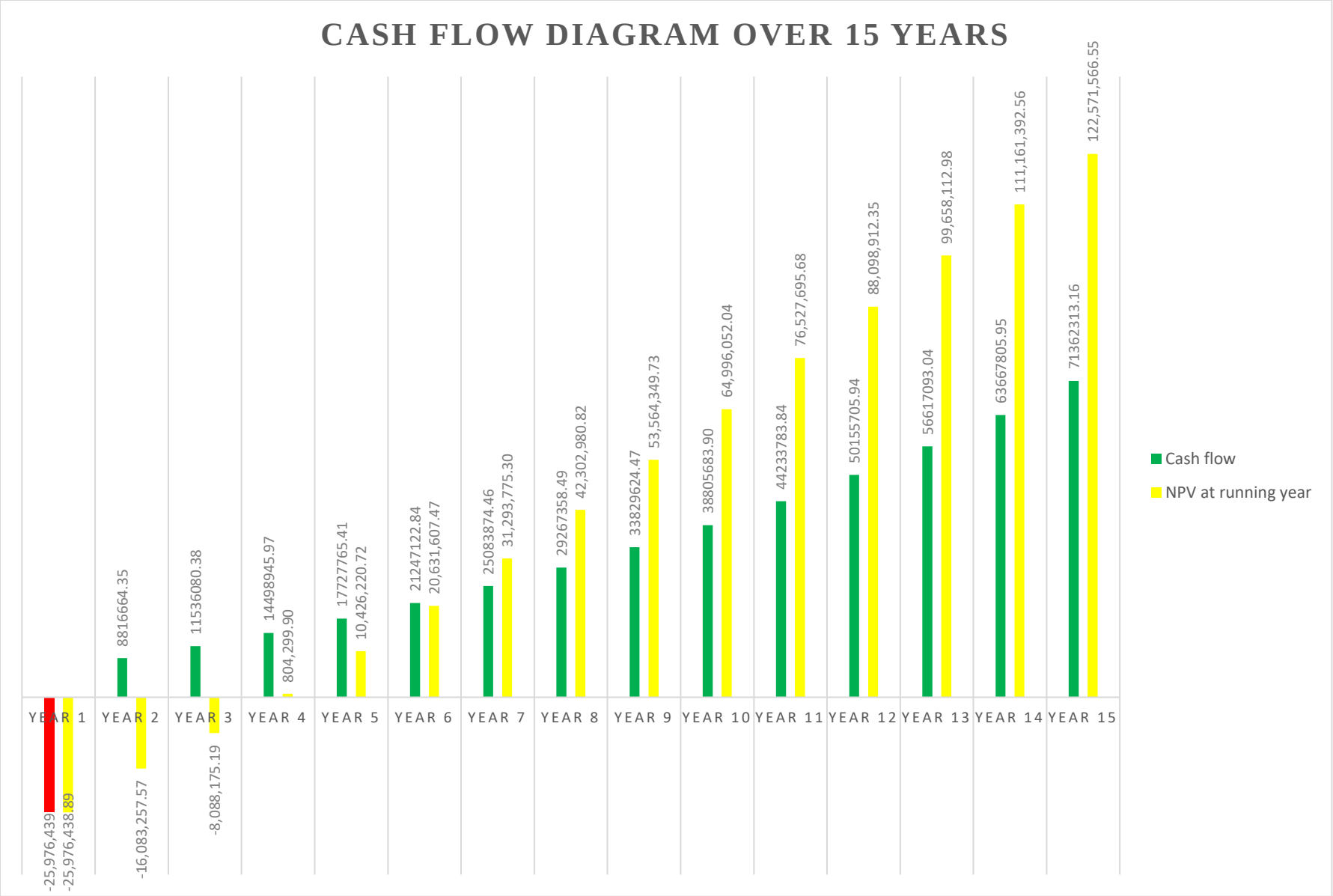


Figure 19 Cash Flow Diagram over 15 years

Analysis of cash flow diagram using Net Present value of cash flow, using formula:

$$NPV\ in\ the\ \ m^{th}\ \ year$$

$$= \sum_{n=1}^{m} \left(\frac{Cash\ flow\ in\ m^{th}\ year}{(1+0.13)^{m}} \right) - cash\ out\ flow\ in\ 1^{st}\ year$$

Cash in flow		Cash out flow	Net present Value
	Year 1	-25,976,439	-25,976,438.89
8816664.35	Year 2		-16,083,257.57
11536080.38	Year 3		-8,088,175.19
14498945.97	Year 4		804,299.90
17727765.41	Year 5		10,426,220.72
21247122.84	Year 6		20,631,607.47
25083874.46	Year 7		31,293,775.30
29267358.49	Year 8		42,302,980.82
33829624.47	Year 9		53,564,349.73
38805683.90	Year 10		64,996,052.04
44233783.84	Year 11		76,527,695.68
50155705.94	Year 12		88,098,912.35
56617093.04	Year 13		99,658,112.98
63667805.95	Year 14		111,161,392.56
71362313.16	Year 15		122,571,566.55

Thus, it was found that NPV becomes positive on the fourth year of investment. This indicates that the factory will break even this year. Any further operation will only add to the wealth of the company. The internal rate of return (IRR) is the maximum rate of return on investment for project such that the net present worth of the project becomes exactly zero at the end of project life. The IRR for this project was also calculated using the following equation:

$$0 = \sum_{n=1}^{15} \left(\frac{Cash\ flow\ in\ m^{th}\ year}{(1+IRR\%)^{m}} \right) - cash\ out\ flow\ in\ 1^{st}\ year$$

The IRR of this project was found to be 56% over 15 years. This indicates that the project is highly feasible.

4.12 Value Addition:

The conventions provide different perspectives on how value added is calculated and understood within economic analysis. The production convention for value addition is the most relevant for this approach of analysis.

Total yearly cost of processing can be tabulated from the yearly cost expense as below:

The total cost of raw material, labor, electricity, chemical, water supply, land lease, machine maintenance and general management to produce 35140kg yarn per annum (i.e., $125.5\frac{kg}{day}x\ 280 working\ day$) is Nrs 33571757.03 in the first year of production. This means, per kg cost of conversion becomes $\frac{33571757.03}{125.5\frac{kg}{day}x\ 280 working\ day}$ = Nrs 955.37/kg. When compared to manual processing cost under Table 5 Cost of Manual processing, the manual processing costs 3887 Rs/ kg, the cost of conversion from the factory is about four times less than manual spinning.

The produced yarn can be solved at B2B cost and revenue can be gained as per previous table.

Table 18 Cost of conversion per kg

Headings Cost of Initial management and yearly operation (C)	QTY	Rates Nrs/ Unit	Asset cost
Legal & Accounting consultant 2x 13 months	26	25000	650000
Salary (3 Skilled Supervisor+ 1 MANAGER) for 13 months i.e., 52-man month	52	35000	1820000
Salary (31 semi-skilled) for 13 months i.e., 403-man month	403	27000	10881000
Land Lease 3.5 ropanis for 1 years (reference value taken based on enquiry for rural Lalitpur)	3.5	20000	70000
Market travel (1 marketing personnel x 10 purchaser x 3 days each) 140-man day travel	30	4000	120000
Raw Material 70-ton Bark for 1 year (reference rate taken based on purchase of raw material for experimentation done for yield)	70000	200	14000000
Cost of Electricity 91.47 KVA Demand charge for 12 months as per (विद्युत महसुल संकलन विनियमावली, २०७८)	1097.64	110	120740.40
Cost of Electricity 58.02 Kw Peak demand for 8 hours, 280 days, 2 years at 9.5 Rs/unit as per (विद्युत महसुल संकलन विनियमावली, २०७८)	129964.8	9.5	1234665.60
Cost of Chemical NaOH (44.88 kg per day for 280 days)	12566.4	300	3769920
Cost of Water supply (3072ltrs/day for 26 days x 12 months) at the KUKL Tariff rates		22822.38	

for 1in Piped water connection (((3.072kl*26day - 56klm minimum quantity for tariff)x71 tariff for quantity above 56kl+3960 minimum charge+9560 monthly fixed charge)x1.5 for sewerage service 50% extra (KUKL, 2079)	12		273868.42
Cost of maintenance of machinery 5% of cost of asset	5%	12631252.2	631,562.61
Total Cost of conversion yearly(Cc)			**33571757.03**

Table 19 Value added per kg

Daily production capacity (a)	125.50	kg
Portfolio	40 Nm Yarn	20 Nm Yarn
Split production capacity (b)	10%	90%
B2B cost (c)	1565.22	1391.30
Product Split in weight (a x b)	12.55	112.95
Daily revenue (a x b x c)	19643.48	157147.83
Total Daily Revenue ∑ (a x b x c)	Nrs 176791.30	
Yearly Revenue ∑(a x b x c) x 280 working days per year	NPR 49,501,565.22	
Total Cost of conversion yearly(Cc)	NPR 33571757.03	
Net Yearly Income (I)	NPR 15929808.19	
Yearly production of yarn (a)x 280 working days	35140 kg	
Value added per kg of yarn (I)/(ax280)	Nrs 453.32/ kg	

Total value added in the process of converting this under-utilized hilly vegetation and converting into yarn is Nrs 453.32/kg. This figure is the economic value extracted per kilogram of produced yarn.

4.13 Effluent treatment:

The daily use of Water: 3072ltrs and NaOH: 44.88 kg (4% x 187 ltrs x 6 batches) dissolved and washed has been documented in table 9. This water has to be safe to dispose as per the generic standards defined by Ministry of Population and Environment under Government's Urban Environmental Management Directive (2011). The standards (attached in the annex 7) dictates the pH of the discharged effluent should 5.5-9.0.

For neutralizing any base, a suitable acid needs to be added to form salt and water. For NaOH, the best salt to be produced in NaCl common salt. For this neutralization reaction is,

$$HCl+NaOH \rightarrow NaCl+H_2O$$

Where each mole of acid reacts with each mole of NaOH to give a mole of NaCl and H_2O.

For NaOH, molar mass being 40gm/mol, meaning 44800 gm of NaOH is 1122 moles NaOH. Thus, 1122 moles of HCl is required to neutralize all the NaOH producing 1122 moles of NaCl and H_2O.

Handling pure HCl gas is extremely hazardous due to its strong acidity and potential to release toxic fumes when it reacts with moisture in the air. In most practical applications, hydrochloric acid is used in aqueous solution. This solution consists of HCl molecules dissolved in water, and its concentration can vary depending on the application. Commercially available hydrochloric acid solutions range from relatively dilute concentrations used in common cleaning products to more concentrated solutions used in industrial processes. Concentrated HCl (fuming or technical grade) is a highly concentrated form of hydrochloric acid, often with concentrations around 35% by weight.

For HCl, molar mass being 35.45gm/mol, 1122 moles of HCl are 39774.9 gm of HCl. Considering 35% HCl solution, the volume of HCl required is $\frac{39774.9}{35}$ =113642.57 milliliter of HCl i.e., 113.64ltrs of 35% HCl will neutralize the solution.

For H_2O, molar mass being 16gm/mol, 1122 moles of H_2O are 17952 gm of H_2O i.e., 17.9ltrs of water is also added to the solution, making a total of 3089.9 ltrs of solution. Including the water added from 113.64 ltrs of 35% HCl, total water content is 3203.54 ltrs.

Thus, the effluents can be neutralized as in the above procedure. The pH can be tested using common lab techniques like use of litmus paper. All the NaOH can be pacified to salt and the water can be disposed to the environment.

CHAPTER FIVE: CONCLUSION:

Upon literature review a gap was found in the existing research, the maximum yield of fiber upon processing was not document else were in any scientific publication. So, the percentage yield of cooking, beating, hackling and manual spinning was examined to be 90.13%, 66.98% and 90.50% and 100% respectively and the aggregated yield of preprocessing was found to be about 54.63%. Yield of carding process was found to be 92%. The aggregated yield including carding process was found to be about 50%. The costs of pre-processing were found to be Nrs 125.9/kg, Nrs 21.65/kg, Nrs 30.45/kg and Nrs 3502/kg, of these manual spinning process seemed to be the most labor intensive. Alternative, mode of spinning has been established by carding and spinning the fiber using industrial machinery.

Also, the most cost-effective location to source fiber from 15 nettle producing districts was analyzed by formulating a cost parameter based on weightage-based distance covered and time taken. Above that, access to electricity and access to market were also other factors considered to choose this location. Based on availability of raw material in the chosen district, Pyuthan, the capacity of this processing plant has been calculated to be 35 ton.

Plant layout was confirmed by assembling 5 different processes in a product layout fashion. The number of machines to be setup was identified based on the processing requirements in each step. Then, the floor plan was developed based on space requirements of each machine and material flow. This defined the functional size of the factory shed along with the sizes of all amenities required to run it. 3 sets Cooking Vessel, 3 sets Beating Machine, 2 sets Hackle Machine,4 set Carding Machine and 63 NMC 10 spindle Charkha were placed in product layout fashion. A factory space 7308 sq. m area was designed to fit raw inventory area, processing area, supervisor office, staff quarter along with amenities like toilets, water well, transformer, and truck parking area.

A total of 75 machines,31 manpower of different levels, daily 421.5 KWhr electricity at 58.02 KW peak power along with 3072 ltrs water and 44.88 kg NaOH was required. The machines can produce 125.5kg yarn daily. The capital investment including civil works, machinery asset and cost of initial management was deduced and yearly expenses was calculated based

on the utility usage above. Increase in yearly expense was seen to increase in land lease, incremental salary to staff and depreciation in the machinery asset.

Finally, capital structure of 70%:30% (Equity: Loan) was used, cost of financing for 30% loan capital, thereby identifying the cost of investment along with cost of yearly operation including the increment of salary, land lease and depreciation. The revenue streams were estimated based on B2B market price of yarns of 2 different thread count and net yearly income was projected. Increasing yearly revenue was projected based on 21-year average increase of gross value added in manufacturing sub sector of Nepal. The net income for each year was calculated and 20% tax was paid. The profit after tax was projected for 15 years into a cash flow diagram Upon study of 15-year cash flow diagram, the project was found to break even at 4^{th} year of commencement and the internal rate of return was found to be 56%, thereby confirming the financial feasibility of the project.

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ANNEXES

Annex 1: Data from MEDEP office on study of 16 Nettle producing districts

Districts	Nuwakot	Ramechhap	Sindhupalchok	Kabhre	Dolakha	Baglung	Parbat	Myagdi	Pyuthan	Jumla	Kalikot	Dailekh	Surkhet	Darchula	Baitadi	Dadeldhura
No. of MEG	4	7	7	1	1	2	10	21	2	1	1	3	3	12	0	1
Collector	10	10	10	5	0	0	18	102	0	0	0	0	0	92	0	12
Yarn	6	68	41	6	7	21	30	124	17	7	10	39	38	72	0	12
Weaving	3	0	0	0	0	0	22	14	9	0	0	0	0	20	0	3
Product maker	1	0	0	0	0	0	6	0	1	0	0	0	0	0	0	0
Total	20	78	51	11	7	21	76	240	27	7	10	39	38	184	0	27
Size of MEG	5	11.14	7.286	11	7	10.5	7.6	11.43	13.5	7	10	13	12.67	15.33	0	27
Potential (Tons)	NA	NA	10	35	20	55	40	73	30	50	36	65	20	22	NA	13
Collection (Tons)	NA	NA	1	0.4	2	0.5	20	7	7.2	25	6	52	15	8	NA	7
Collection (%)	NA	NA	10	1.143	10	0.909	50	9.589	24	50	16.67	80	75	36.36	NA	53.85
Yarn (Kg)	NA	3,000	4,575	100	30	200	4,800	1,800	7,200	10	60	50	40	600	425	1,000
0Fabric (Meter)	0	0	0	0	0	0	4,763	40	60	0	0	0	0	225	0	250

Annex 2: Data for inter district distances between the considered districts

District	Ramechhap	Sindhupalchok	Kabhre	Dolakha	Baglung	Parbat	Myagdi	Pyuthan	Jumla	Kalikot	Dailekh	Surkhet	Darchula	Baitadi	Dadeldhura
Ramechhap	0	168	113	112	431	413	443	620	1015	900	856	786	1164	1025	976
Sindhupalchok	168	0	66.7	115	365	347	379	514	915	832	755	686	1064	925	876
Kabhre	113	66.7	0	101	306	283	316	511	851	769	692	622	1000	883	812
Dolakha	112	115	101	0	405	382	422	610	949	867	790	721	1099	959	911
Baglung	431	365	306	405	0	18	24.3	158	728	645	568	499	876	737	688
Parbat	413	347	283	382	18	0	30	172	703	621	543	474	852	747	664
Myagdi	443	379	316	422	24.3	30	0	179	744	662	585	516	894	754	706
Pyuthan	620	514	511	610	158	172	179	0	505	425	346	277	655	515	467
Jumla	1015	915	851	949	728	703	744	505	0	84	199	229	529	391	343
Kalikot	900	832	769	867	645	621	662	425	84	0	117	147	447	309	261
Dailekh	856	755	692	790	568	543	585	346	199	117	0	69.9	483	344	295
Surkhet	786	686	622	721	499	474	516	277	229	147	69.9	0	544	406	358
Darchula	1164	1064	1000	1099	876	852	894	655	529	447	483	544	0	140	188
Baitadi	1025	925	883	959	737	747	754	515	391	309	344	406	140	0	48.7
Dadeldhura	976	876	812	911	688	664	706	467	343	261	295	358	188	48.7	0

Annex 3: Data for time taken to travel between various districts and the considered district.

	Ramechhap	Sindhupalchok	Kabhre	Dolakha	Baglung	Parbat	Myagdi	Pyuthan	Jumla	Kalikot	Dailekh	Surkhet	Darchula	Baitadi	Dadeldhura
Ramechhap	0	308	231	261	816	782	841	1004	1740	1560	1326	1185	1800	1560	1440
Sindhupalchok	308	0	138	220	700	671	735	985	1680	1440	1258	1112	1740	1500	1380
Kabhre	231	138	0	180	585	540	606	900	1500	1326	1125	982	1620	1394	1245
Dolakha	261	220	180	0	726	690	795	1050	1680	1500	1269	1140	1800	1500	1410
Baglung	816	700	585	726	0	42	69	420	1350	1147	945	799	1440	1170	1065
Parbat	782	671	540	690	42	0	58	433	1305	1110	900	750	1410	1185	1020
Myagdi	841	735	606	795	69	58	0	465	1410	1215	1020	870	1500	1230	1140
Pyuthan	1004	985	900	1050	420	433	465	0	930	729	534	390	1035	750	654
Jumla	1740	1680	1500	1680	1350	1305	1410	930	0	210	480	546	1110	825	732
Kalikot	1560	1440	1326	1500	1147	1110	1215	729	210	0	138	354	915	630	540
Dailekh	1326	1258	1125	1269	945	900	1020	534	480	138	0	150	972	690	588
Surkhet	1185	1112	982	1140	799	750	870	390	546	354	150	0	900	620	525
Darchula	1800	1740	1620	1800	1440	1410	1500	1035	1110	915	972	900	0	282	390
Baitadi	1560	1500	1394	1500	1170	1185	1230	750	825	630	690	620	282	0	101
Dadeldhura	1440	1380	1245	1410	1065	1020	1140	654	732	540	588	525	390	101	0

Annex 4: Data of Gross Value Added in Millions of current values as per (CBS,2022).

NSIC	Industrial Classification	2000/01	2001/02	2002/03	2003/04	2004/05	2005/06	2006/07
A	Agriculture and forestry	153781	163925	170634	183621	196686	208591	223536
B	Fishing	1844	2165	2168	2504	2682	3113	3287
C	Mining and Quarrying	1817	2149	2310	2507	2748	3134	3417
D	Manufacturing	38409	37736	38826	41673	44885	47840	52172
E	Electricity gas and water	7750	9138	11447	11974	12782	13172	14841
F	Construction	25585	28838	30955	33254	36644	40952	45099
G	Wholesale and retail trade	69928	64778	68695	79219	79839	90214	92648
H	Hotels and restaurants	8459	7143	7540	8942	8895	9398	10043
I	Transport, storage and communications	31425	34959	39362	46283	51336	61250	69555
J	Financial intermediation	11455	12202	12861	13728	17342	21979	28467
K	Real estate, renting and business activities	35267	36525	38251	39991	49242	60042	70791
L	Public Administration and defense	5288	7237	8070	8019	9548	10967	12227
M	Education	17372	20823	24582	26313	31671	34996	40939
N	Health and social work	4178	4626	5408	5825	7017	7842	8568
O	Other community, social and personal service activities	12896	11808	12436	14140	15262	16840	21774
-	Total GVA including FISIM	425,454	444,052	473,545	517,994	566,579	630,330	697,364
-	Financial Intermediation Services Indirectly Measured (FISIM)	12026	13655	13221	17294	18094	19212	21505
-	Gross Domestic Product (GDP) at basic prices	413,428	430,396	460,325	500,699	548,485	611,118	675,859
-	Taxes less subsidies on products	28090	29046	31906	36050	40927	42966	51968
-	Taxes on Products		-	-	-	41266	-	-
-	Subsidies on Products		-	-	-	339	-	-

NSIC	Industrial Classification	2007/08	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14
A	Agriculture and forestry	243323	305477	391519	473270	500465	527869	585951
B	Fishing	3868	4076	4236	4879	5819	6646	8659
C	Mining and Quarrying	4375	5084	5926	6956	8166	9569	11003
D	Manufacturing	57185	65447	70924	80531	91164	100312	112995
E	Electricity gas and water	15219	14629	15244	16002	17518	20553	21362
F	Construction	54134	63741	77289	89356	98539	109488	126364
G	Wholesale and retail trade	105306	124121	161067	179306	198164	229872	271573
H	Hotels and restaurants	11503	13943	17347	21057	25307	29886	35309
I	Transport, storage and communications	76818	92618	95304	105834	122354	140735	155765
J	Financial intermediation	33539	39100	46083	50111	58529	62183	79363
K	Real estate, renting and business activities	73636	81625	93747	106236	123213	139157	152984
L	Public Administration and defense	14352	18556	21695	24830	30547	32236	44324
M	Education	48722	62642	61384	67739	81797	91566	115254
N	Health and social work	10963	13744	15382	17087	20431	22327	27725
O	Other community, social and personal service activities	26500	34089	41423	46947	55461	58026	73541
-	Total GVA including FISIM	779,442	938,890	1,118,571	1,290,142	1,437,474	1,580,426	1,822,173
-	Financial Intermediation Services Indirectly Measured (FISIM)	24185	29362	35156	41660	49992	55205	63435
-	Gross Domestic Product (GDP) at basic prices	755,257	909,528	1,083,415	1,248,482	1,387,482	1,525,221	1,758,738
-	Taxes less subsidies on products	60401	78744	109358	118472	139862	169790	205802
-	Taxes on Products		-	-	-	41266	-	-
-	Subsidies on Products		-	-	-	339	-	-

NSIC	Industrial Classification	2014/15	2015/16	2016/17	2017/18
A	Agriculture and forestry	616572	645697	681062	737322
B	Fishing	9328	11082	12377	13438
C	Mining and Quarrying	11875	11630	14233	16872
D	Manufacturing	118980	120967	133862	146589
E	Electricity gas and water	22051	21180	30623	32407
F	Construction	139289	141318	175300	206737
G	Wholesale and retail trade	289566	293248	323827	360769
H	Hotels and restaurants	40479	41459	47728	55679
I	Transport, storage and communications	164976	167405	178296	216891
J	Financial intermediation	91406	107758	135375	172294
K	Real estate, renting and business activities	166947	191325	267392	309360
L	Public Administration and defense	51422	52720	71421	78252
M	Education	129363	141613	173589	195090
N	Health and social work	32929	33708	42174	45724
O	Other community, social and personal service activities	86521	96545	123773	133296
-	Total GVA including FISIM	1,971,706	2,077,653	2,411,031	2,720,722
-	Financial Intermediation Services Indirectly Measured (FISIM)	72616	84093	103445	119783
-	Gross Domestic Product (GDP) at basic prices	1,899,089	1,993,560	2,307,586	2,600,939
-	Taxes less subsidies on products	231060	259603	335010	406307
-	Taxes on Products	2014/15	2015/16	2016/17	2017/18
-	Subsidies on Products	616572	645697	681062	737322

Annex 5: Data of Electricity Generation Scenario as per PPA signed and in progress(NEA,2022).

Year	FY	PPA Completed	PPA IN Process		PPA Pipeline (CA Completed)		Yearly completed	Cumulative Generated power	Yearly completed	Cumulative Generated power	Demand Forecast (Load forecast Report, 2015)
		MW	RoR (kW)	PROR (kW)	ROR (kW)	PROR (kW)	MW	PPA Completed	MW	All up to PPA in pipeline	
	Current Installed Capacity							2190		2190	2562.1
1	2080/81	950,850					951	3,141	951	3,141	2764.5
2	2081/82	940,798					941	4,082	941	4,082	2978.3
3	2082/83	907,347					907	4,989	907	4,989	3203
4	2083/84	910,532	34,950	3,412			911	5,900	949	5,938	3439.5
5	2084/85	983,945	242,463	113,851	165,114	9,840	984	6,883	1,515	7,453	3688.7
6	2085/86	893,411	185,864	558,780	709,143	42,970	893	7,777	2,390	9,843	3971.7
7	2086/87	106,000	553,385	697,490	409,127	186,011	106	7,883	1,952	11,795	4,281
8	2087/88	180,000	258,600	340,423	525,000		779	8,662	1,304	13,099	4614.4
9	2088/89			216,000			216	8,878	216	13,315	4974.9
10	2089/90					1,061,000	-	8,878	1,061	14,376	5364.5
	Total	5,872,883	1,275,262	1,929,956	1,808,384	1,299,821	6688		12186		

Annex 6: Civil Rate Analysis for the construction of factory shed

Factory Building -Himalayan Nettle Yarn processing Udhyog

Pyuthan

S.N.	Particulars	Quantity	Unit	Rate	Amount
1	**SITE PREPARATION**				
	Preparation of site including levelling ground, cutting trees, removing away bushes, remains of old building like concrete by chipping, removing loose earth, soil and brick- bats etc. as per direction, specification and instruction of the Site engineer, all complete .	1.00	Ls.	75,000.00	**75,000**
2	**EARTHWORK IN EXCAVATION**				
	Earth work in excavation in foundation for truss column footing including 12 columns of 0.9m*0.9m*0.9m at main factory shed+16 column 0.6m*0.6m*0.6m for staff quarter, inventory, office etc. as per drawings	14.64	cum	600.44	**8,793**
3	**EARTHWORK IN BACKFILLING**				
	Earth work in backfilling in foundation and flooring including proper compaction with sprinkling of water considering 20 % backfill of excavation	2.93	cum	635.76	**1,862**
4	**DRY BRICK FLAT SOLING**				

	Laying of Brick for soling in foundation including application of sand between bricks over proper compacted earth at the column footing 12 columns of 0.9m*0.9m at main factory shed+16 column 0.6m*0.6m and perimeter of factory 2*(27m +14.6m)*0.6m as per drawings, specification and instruction of the Site engineer, all complete.	65.40	sqm	1,120.00	**73,248**
5	**PLAIN CEMENT CONCRETE**				
	Providing and laying, plain cement concrete 200mm in foundation and floor with cement, sand and aggregates in 15m x 27m for process machinery, 15m x 5m staff quarter, 3m x 9m supervisor's office, 16.4m x 6.4mfor inventory including mixing, laying in panels providing proper slopes, lines and level and curing, as per drawings, specification and instructions of the Site Engineer, all complete.				
	a) P.C.C.of (1:3:6) mix	122.39	cum	13,288.52	**1,626,409**
6	**RCC**				
	Providing and laying, concrete for R.C.C. columns footings as per item 2 and truck parking area (10.8m x 6m x 0.2m) and all kinds of RCC works with cement, sand and aggregates including mixing, laying, curing finishing etc. excluding reinforcement and formworks as per drawings, specification and instruction of the Site Engineer, all complete.				

	a) M20	27.60	cum	18,200.00	**502,407**
7	**STEEL REINFORCEMENT**				
	Providing and laying, steel reinforcement bar including straightening, cleaning, cutting, bending, binding with 20 SWG annealed tying wire and fixing in positions as per drawings, specifications and instructions of the Site Engineer, all complete.	5,318.00	kg	115.00	**611,570**
8	**FORMWORK**				
	Providing and laying, centering and shuttering with approved materials for all kinds RCC works including all necessary mild steel propping, scaffolding, staging, supporting, etc. all complete net as per drawings, specifications and instructions of the Site Engineer, all complete.	157.84	sqm	804.00	**126,903**
10	**PREFAB WALL**				
	a) Providing and laying of 6mm thick Cement Board for walls with all included aluminum support works and joint sealings and finishing staff quarter 15m x 5m , supervisor office 3m x 9m and toilet 1.3m x 3.2m as per drawing, specification and instruction of site Engineer, all complete.	222.90	sqm	3,450.00	**769,005**
11	**FALSE CEILING**				
	Supplying and installing Water Repellant Gypsum Board False ceiling works for staff quarter 15m x 5m , supervisor office 3m x 9m and toilet 1.3m x 3.2m as per drawings,	106.16	sqm	1,183.60	**125,651**

	specification and instruction of the Site Engineer, all complete.				
12	**ALUMINIUM WORKS**				
	Supplying and fitting Aluminum door section frame 4 small door of 0.9m x 2.1m with 5mm glass and necessary accessories as per drawings, specification and instruction of Engineer, all complete.	7.56	sqm	5,380.00	**40,673**
13	**ROLLING SHUTTER / MS Heavy gates**				
	Supplying and fitting Mild steel Rolling shutter frame and shutters 6m x 3m at entrance and exit of factory truss with provision of manual operation as per drawings, specification and instruction of Site Engineer, all complete.	18.00	sqm	4,000.00	**72,000**
14	**STEEL WORKS FOR TRUSS**				
	Fabricating and Installing IS standard steel sections in Truss including cleaning, cutting, welding, and erection and fixing in positions including primer ad paint as per drawings, specifications and instructions of the Site Engineer, all complete.	8,257.00	kg	120.00	**990,840**
15	**PAINTING & COLORING**				
	Supplying and painting necessary primer to give uniform color after rendering surface clean and moist as per specifications and instruction of the Site Engineer, all complete.				
16	**H Span Sheets wall**				

	Supply and installation of 26 Gauge H Span Sheet for 3m high staff quarter 15m x 5m , supervisor office 3m x 9m and toilet 1.3m x 3.2m and processing shed 27m x 14.6m x 6m high including all necessary J hooks, washers, nuts and bolts as per drawings, specification and direction of Site Engineer, all complete	722.10	sqm	1,200.00	**866,520**
16	**H Span Sheets roof**				
	Supply and installation of 26 Gauge H Span Sheet for 1:12 gradient roof staff quarter 15m x 5m , supervisor office 3m x 9m and toilet 1.3m x 3.2m and processing shed 27m x 14.6m x 6m high including all necessary J hooks, washers, nuts and bolts as per drawings, specification and direction of Site Engineer, all complete	651.26	sqm	1,200.00	**781,508**

Area=		676.76	**Total of Civil Works**	**6,672,389**
Rate per sqft	1,029.67		**VAT**	**867,411**
			Total of Civil Works	**7,539,800**